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A REPORT ON THE DEVELOPMENT OF ROASTING TECHNOLOGY FOR GOLD BEARING ARSENICAL SULPHIDE CONCENTRATES

To

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SUMMARY

The design, construction and preliminary commissioning trails of a two stage laboratory-scale fluidized bed roaster for process development in the treatment of arsenical sulphide concentrates were funded from RPC's Industrial Research and Technology Transfer Program to assist its industrial clients. CANMET's participation allowed for the completion of commissioning of the new test facility.

Commissioning runs using Giant Yellowknife Mines Ltd. bulk sulphide float concentrate took place during the period of April 10 to May 5, 1989. Average feedrates during the three commissioning runs varied from 13.1 to 15.9 kg/hr and bed temperatures in the first stage varied between 517°C to 557°C and in the second stage between 494°C to 527°C. The first stage was always kept at reducing conditions to volatilize the arsenic. Actual airflows were between 63% to 78% of the stoichiometric oxygen to convert all the sulphides to magnetite. Arsenic removal in the first stage was 92%. Oxidizing conditions were maintained in the second stage with actual airflows at 115% to 169% of the stoichiometric oxygen.

Roasting control at Yellowknife is largely visual to obtain a product with a chocolate brown colour. The calcines produced during the commissioning trials were consistently this chocolate brown. Sulphur reduction in the final calcine was 90% at 1.9% S and 70% in the first stage at 6.1% S. The first stage calcine was consistently black.

Gold extraction efficiencies calculated for head and residue fire assays after 24 hour bottle roll tests on the final calcines averaged 78% for 21 tests. The maximum extraction from all the tests was 91% which was taken while airflows to the second stage were doubled, resulting in a red calcine. An additional series of bottle roll cyanide leach tests were carried out on a bulk sample to test the effect of the variables on the leachability. Fine grinding increased the extraction from 81.14% to 84.64%.

Commissioning of the pilot two stage roasting facility was satisfactorily demonstrated and process control was achieved. While gold extraction from the test calcine was lower than achieved industrially by Giant Yellowknife further work is required to determine whether this is a function of the test roaster, the cyanidization process or both.

SUMMAIRE

La conception, l'aménagement et les essais de mise en service préliminaires d'un four de grillage à lit fluidisé de dimension laboratorie à deux étapes pour las mise au point d'un procédé afin de traiter les concentrés de sulfure d'arsenic ont été subventionnés par le programme de recherche industrielle et de transfert de la technologie du CRP afin d'aider ses clients industriels. Grâce à la participation du CANMET, la mise en service de la nouvelle installation d'assai a été achevée.

Des essais de mise en service ont été effectués du 10 avril au 5 mai 1989 en utilisant un concentré de sulfure en vrac par flottation de Giant Yellowknife Mines Ltd. Les taux d'alimentation moyens enregistrés pendant les trois essais de mise en service variaient de 13.1 à 15.9 kg/h tandis que les températures du lit durant la première étape variaient de 517°C à 557°C. Durant la deuxième étape, elles variaient de 494°C à 527°C. La première étape a toujours été maintenue à des conditions basses afin de volatiliser l'arsenic. Les débits réels d'air variaient de 63% à 78% de l'oxygène stochimétrique afin de convertir tous les sulfures en hematite. Le retrait de l'arsenic durant la première étape s'élevait à 92%. Les conditions oxydantes ont été maintenues pendant la deuxième étape; les debits réels d'air variant de 115% à 169% de l'oxygène stochimétrique.

Le contrôle du grillage à Yellowknife est en grande partie visuel afin d'obtenir un produit de couleur brun chocolat. Les calcinats produits pendant les essais de mise en service étaient de couleur brun chocolat constant. La réduction du soufre dans le dernier calcinat était de 90% à 1.9% de S et 70% dans la premiére étape à 5.1% de S. Le calcinat de las premième étape était toujours noir.

L'efficacité de l'extraction de l'or calculée pour les pyroanalyses des résidus et des matières de combustion après la cyanuration des derniers calcinats s'élevait a environ 78% pour 21 essais. L'extraction maximale de tous les essais s'élevait à 91%; extraction effectuée lorsque les débits d'air à la deuxième étape étaient doublés, ce qui a entraîné des calcinate rouges. Une autre série de cyanurations a été effectuée sur un échantillon en vrac afin de vérifier l'effet des variables sur la capacité de lixiviation. En raison du broyage fin, l'extraction est passée de 81.14% à 84.64%.

Ce projet de mise en service de l'unité n'était pas un programme d'essais. Le rendement de l'usine ne doit donc pas être jugé d'après les résultats obtenus.

Des essais de mise en service du four de grillage à lit fluidisé de demension de laboratorie á deux étapes, on été démontrés avec satisfaction et contrôlé de la processure a été effectués. L'extraction de l'or des calcinats ont été moins que celles réussis à Giant Yellowknife. Du travaille additionnel est requis pour sovoir si ceci est une fonction du four de grillage, le cyanuration ou les deux.

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1.0 INTRODUCTION

The initiative to apply roasting technology to gold roasting follows from work for Giant Yellowknife Mines Ltd. on crude arsenic baghouse dust to recover pure arsenic trioxide leaving a gold residue calcine for treatment by cyanidation. This arsenic fuming test facility has been modified to provide a two stage laboratory-scale fluidized bed roaster for the process development in the treatment of gold-bearing arsenical sulphide concentrates to meet the needs of the Canadian mining industry

Design, construction and preliminary commissioning trials were funded from RPC's Industrial Research and Technology Transfer Program to develop this capability to assist its industrial clients. CANMET's participation allowed for completion of commissioning of the new test facility. Giant Yellowknife Mines Ltd.'s participation in providing gold sulphide float concentrate and their Dorco-Roaster operation parameters was essential.

The recovery of gold from refractory ores has received considerable attention in recent years. Many gold-bearing ore bodies have been discovered where gold is not amenable to cyanidation and thus by definition is refractory. A large number of processes have been developed including roasting, pressure oxidation, bio-oxidation, nitric acid or oxide oxidation, chlorination, chlorine based pressure oxidation, ultra fine milling, carbon-in-pulp leach, pre-aeration and intensive cyanidation. Of the above processes roasting and pressure oxidation are the processes most frequently chosen. Roasting in many cases is the only successful process for the treatment of arsenical-antimonial refractory gold ores. Most of the gold at the Giant Yellowknife Mine is believed to occur as submicroscopic inclusions or solid solution in arsenopyrite. Visible gold is rare. Direct cyanidation of the ore yields about 30% of the gold.

Much of today's state-of-the-art roasting of arseniferrous concentrate was developed from the Giant Yellowknife Mine's operation in Yellowknife, NWT. Gold flotation concentrates were first roasted in an Allis Chalmers, Edwards-type hearth duplex roaster, which went into operation in 1949. In 1952 a prototype two-stage fluosolids roaster was

installed to accommodate an expansion in the mill throughput. After several years of operation a larger two-stage fluosolids roaster was installed in 1958 to do all the roasting and accommodate a further expansion.

The first stage reactor serves to remove arsenic under reducing conditions in the arsenious state as As_2S_3. Oxidizing conditions would promote the formation of trivalent arsenic to pentavalent arsenic which would remain with the calcine as a ferric arsenate surface coating, retarding further arsenic volatilization and inhibiting dissolution of gold.

The second stage reactor serves to oxidize pyrite. Sulphur is removed, however, total elimination as in a dead roast would promote oxidation of iron to hematite, while occluding the calcine pores and preventing the penetration of cyanide solution. Roaster operating parameters and typical stream analyses are given in Table 1 and the Giant Yellowknife two stage roasters are illustrated in Figure 1. Airflow requirement calculations are given in Table 2.

Roasting is controlled by varying the air, concentrate feed rate and water addition. The concentrate is roasted down to 3% sulphur to attain a chocolate brown colour. Control is both visually based on colour and through observation of bed temperatures. Typical gold extraction efficiency by cyanide is 94%.

The following report outlines the plant modifications and preliminary commissioning runs (March 20-31) which was the main activity funded by RPC's Industrial Research and Technology Transfer Program and three commissioning runs (April 10-12, April 17-20 and May 2-3) the principal activities of the DSS Contract (Appendix A).

TABLE 1

GIANT ROASTER OPERATING PARAMETERS AND TYPICAL STREAM ANALYSES

	TPD	Au (oz/ton)	Fe %	S %	As %	Sb %
Mill Feed	1250	0.19	6.60	2.20	0.85	0.04
Flotation Concentrate	130	1.60	23.00	17.50	7.60	0.18
Roaster Calcine	100	2.00	27.00	2.50	1.00	0.13
ESP	22	1.43	18.00	2.75	2.29	0.30
Baghouse	15	0.12	1.75	0.50	70.00	0.50

	STAGE 1	STAGE 2
Air Flow	2500 CFM	950 CFM
Bed Temperature	496•C	513•C
Freeboard Temp.	403•C	463•C
Bed Diameter	11.5 '	9.5 '
Arsenic Elimination	87%	87%
Sulphur Elimination	84%	88%
Feed rate	6.11 TPH	4.53 TPH
O_2	0.2%	1.2%
Air Ratio	0.8	1.4

FIGURE 1

GIANT YELLOWKNIFE MINES LTD.

ROASTING CONDITIONS

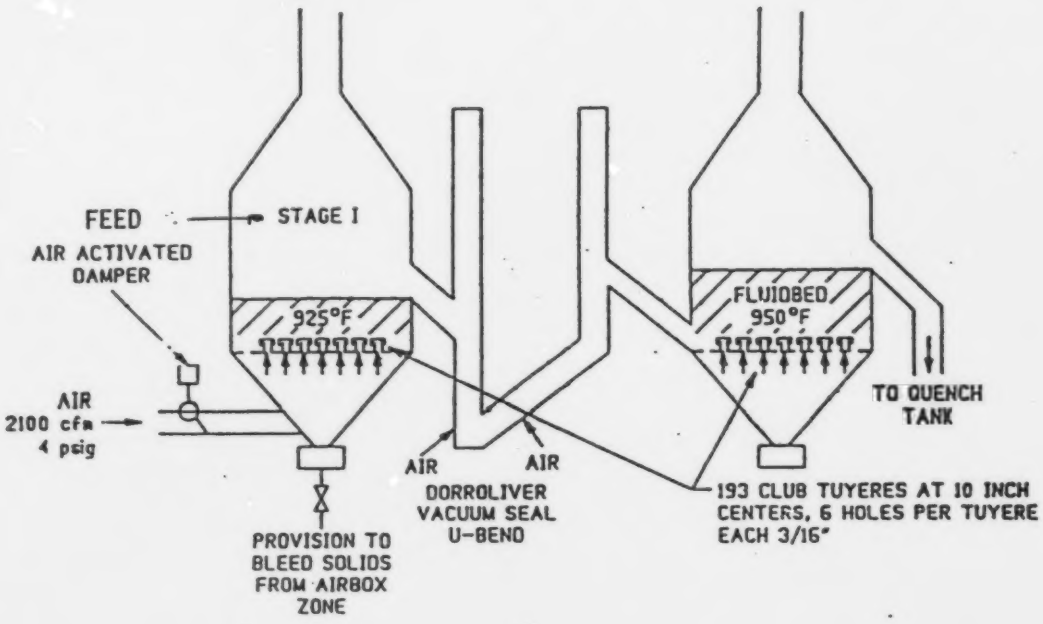


TABLE 2

AIRFLOW REQUIREMENTS

FEED RATE :	5555	kg/hr	= 6.11 tph		
% Pressure	100.0				
FEED ASSAY :					
Fe(%)	23.0				
As	7.6				
Sb	0.6				
S	17.5				
Au(oz)	2.26				
% S in Asp	4.0				
% S in Py	13.5				
% Pyrite	25.2				
% Asp	17.8				
Rate of Asp	983.7	kg/hr			
Rate of Py	1393	kg/hr	FLOWRATE:	1kgmol=838.2 ft3	
O2 req'd(Asp)	15.7	mol/h	63084	SCFH Air	
O2 req'd(Py)	31.9	mol/h	128035	SCFH Air	
		TOTAL =	191119	SCFH Air	
Air requirements:					
1st stage	152896	SCFH =	2548	SCFM Air	
2nd stage	42046	SCFH =	701	SCFM Air	
Elemental distribution:			Fe	S	As
	Pyrite	%	11.7	13.5	–
	Asp	%	6.2	4.0	7.6

Fr. CIMM					
	Airflow	(SCFM)	2500	FEEDRATE:	5.6 tph
					186.7 lb/min
				FACTOR---	13.4

2.0 PROCESS EQUIPMENT

The initial phase of the project involved a visit to the Giant Yellowknife Mine, Yellowknife, NWT, (January 31 - February 2) to familiarize RPC with their roaster plant operations. The signing of a "non disclosure" agreement enabled a transfer of key roaster plant operating parameters. The knowledge gained on Giant Yellowknife process equipment and operating parameters was used in the design and modifications to the existing roasting facility at RPC to achieve similar calcines.

The existing facility consisted of a 6" fluidized bed roaster, high temperature or "hot baghouse", arsenic trioxide condenser and low temperature or "cold baghouse". A venturi/packed tower scrubber with reaction/caustic make-up tank is used for off-gas cleaning (SO_2). All plant effluents are pumped into a mixing tank for liming and ferric sulphate addition. Sludge is separated in one of two pan filters and finally to a holding tank where effluents are tested prior to their disposal.

An 8" fluidized bed roaster was added ahead of the existing 6" unit for the first stage reduction roast in modifying the equipment for gold roasting. Roaster design incorporates features associated with commercial scale units, consisting of plenum, distributor plate, tuyeres, hearth section, transition section (second stage) and freeboard. The new roaster has been placed at a higher elevation so the bed overflows into the second stage 6" roaster. The off-gas from the first stage roaster entered the second stage roaster freeboard. A 1.5" rotary airlock valve was added to the first stage overflow pipe to prevent short circuiting of off-gas and elutriated calcine. A baffle plate was added to the second stage shell to prevent short circuiting of first stage calcines. Two 1.5" nozzles for first stage off-gas and calcine overflow and a 1" nozzle for coolant was added to the existing 6" or second stage roaster shell. The overflow nozzle in the first stage was fixed at 1 meter leaving a freeboard height of 2 meters. Additional 1" nozzles were provided for underbed and overbed dry feeding, coolant/slurry feeding and thermocouple/pressure top nozzles (1/2").

Both first and second stage roaster shells, nozzles, plenum and off gas pipes are entirely constructed of 316 stainless steel. There is no refractory lining other than the burner and air box. All roaster and off-gas train external shells were wrapped with electrical coils to provide the additional heat required during start-up and to prevent arsenic condensing in the off-gas and train. The outer layers were insulated with 4" of ceramic fibre followed by 1" of aluminum backed fibreglass. Air was heated initially during start-up using a propane burner in the first stage and an electric preheater in the second stage. Due to the size limitations (8" diameter) slurry feeding, as the case is at Yellowknife, was not possible.

Dry feeding using transport to the first stage from a volumetric screw-live bottom bin feeder, mounted on a weigh scale was utilized. Two-fluid (air/water) or pressure (water) nozzles, mounted on lances were used for direct cooling and temperature control of the first and second stages. Nextel ceramic fibre high temperature filter bags were used in the hot baghouse to filter out non volatile elutriated dusts from the second stage reactor. Although ceramic bags are less reliable than sintered porous metal filters they were selected because of their lower operating pressure drop, 1-5" H_2O, and were needed for the increased volume of off-gas due to the additional 8" roaster which is in series with the 6" roaster. The original baghouse design with 0.5 micron filters was acceptable for the 6" roaster used for the original arsenic fuming trials. A coarser 10 micron porous metal filter may have been able to operate with the two roasters in service, however, long deliveries of porous metal filters from the supplier made this option impossible.

The two stage fluidized bed roasters are illustrated in Figure 2 and a process flowsheet is illustrated in Figure 3. Figure 4 illustrates the design of the 8" distributor plate.

FIGURE 2

TWO STAGE FLUIDIZED BED ROASTERS

FOR REDUCTION/OXIDATION TREATMENT

OF REFRACTORY GOLD-BEARING CONCENTRATES

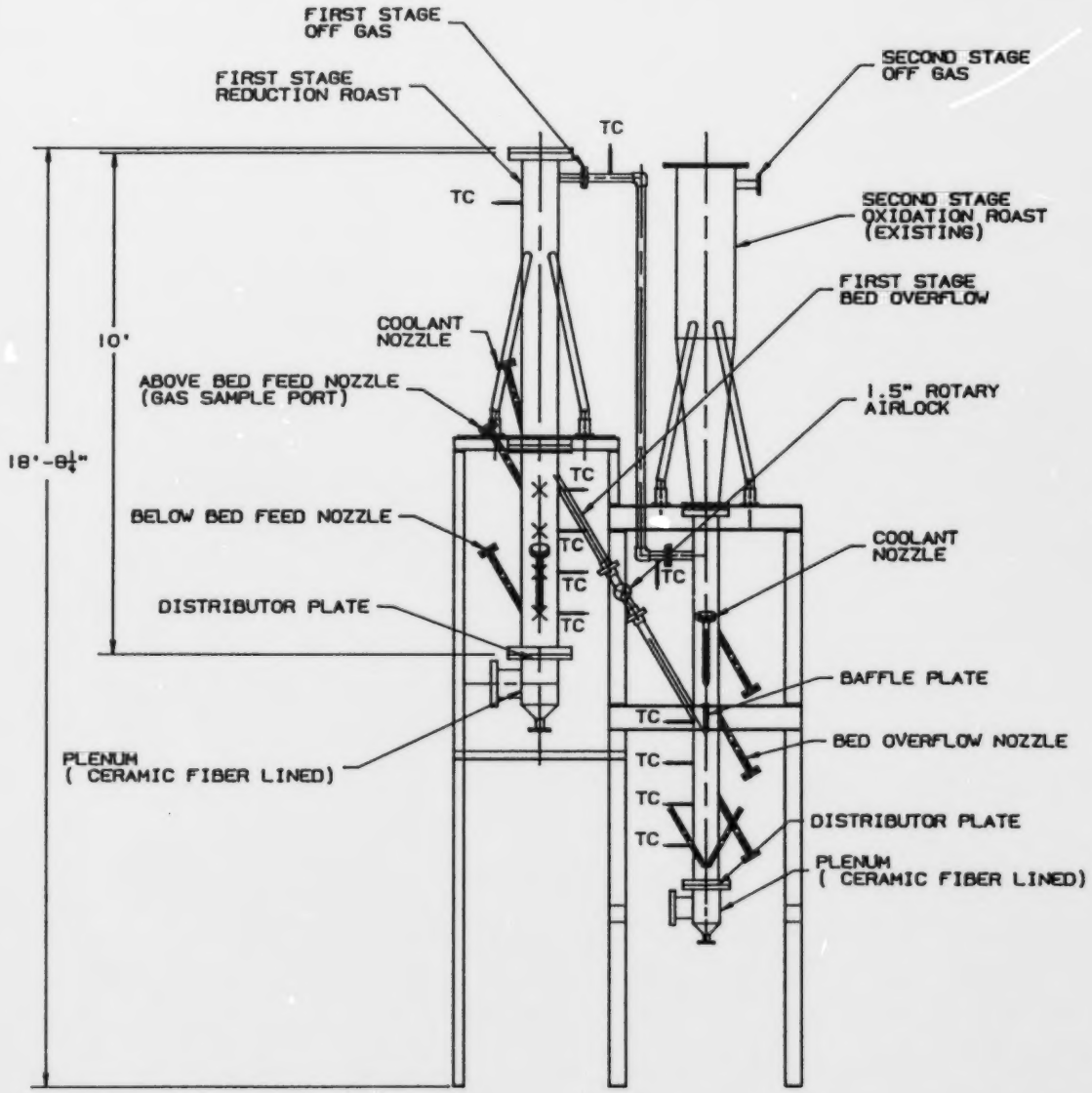


FIGURE 3

TPW STAGE FLUIDIZED BED ROASTERS
FOR REDUCTION/OXIDATION TREATMENT
OF REFRACTORY GOLD-BEARING CONCENTRATES

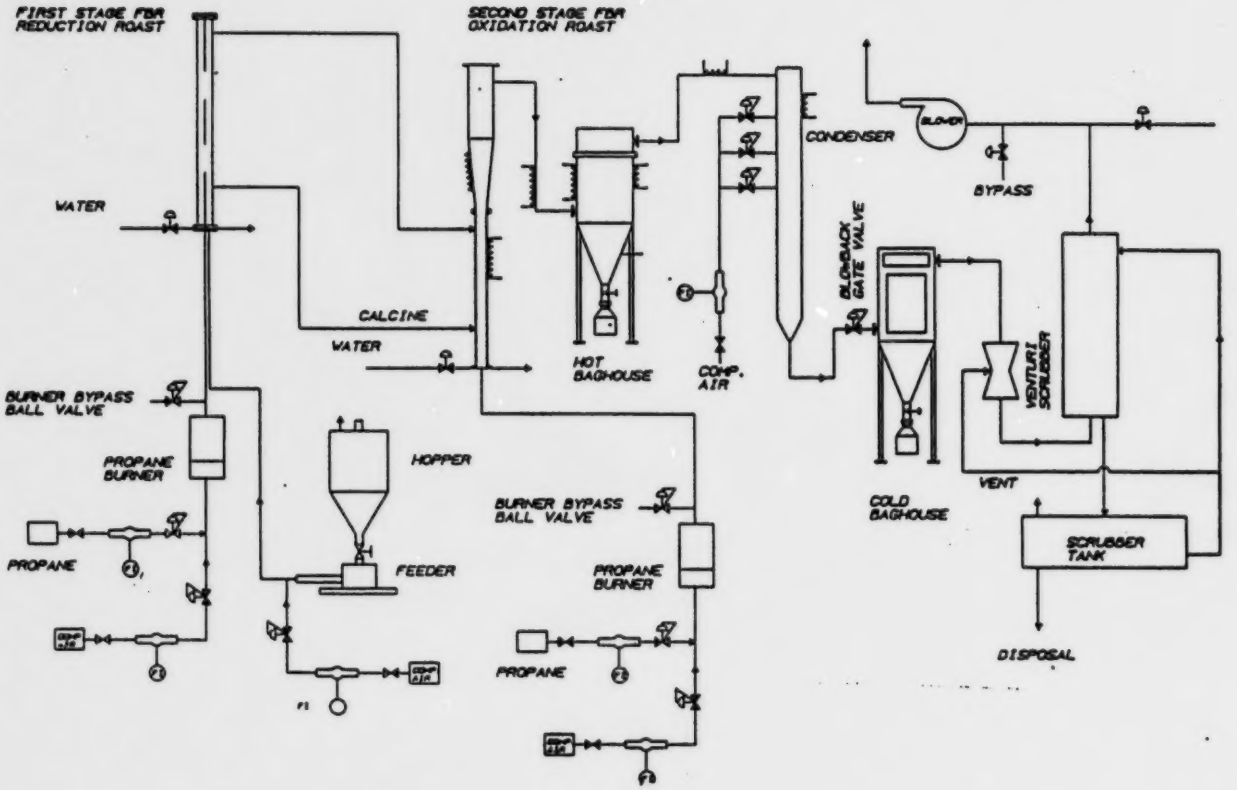
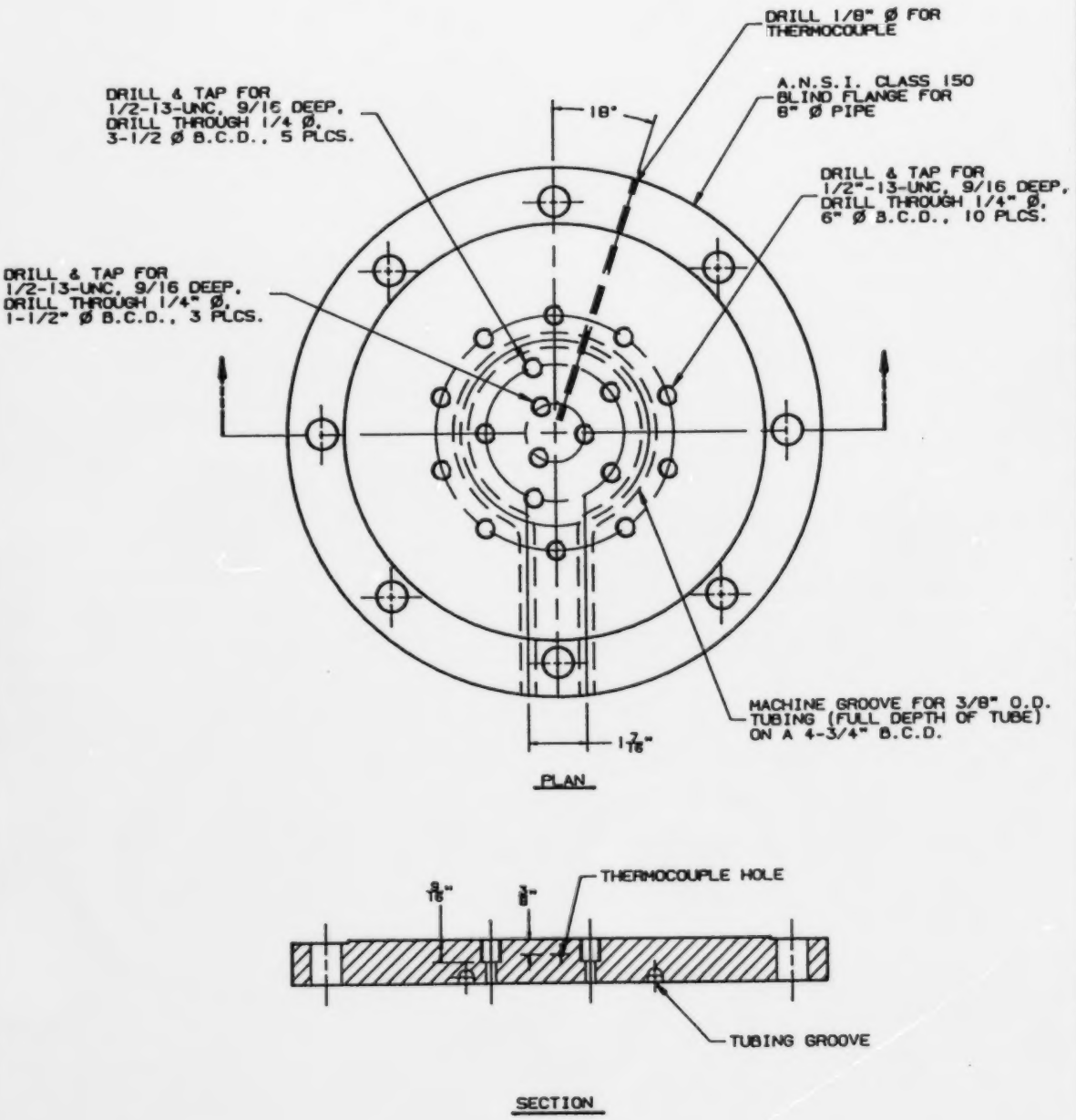


FIGURE 4

DISTRIBUTOR PLATE


DRILL 1/8" Ø FOR THERMOCOUPLE
A.N.S.I. CLASS 150 BLIND FLANGE FOR 8" Ø PIPE
18°
DRILL & TAP FOR 1/2-13-UNC, 9/16 DEEP, DRILL THROUGH 1/4 Ø, 3-1/2 Ø B.C.D., 5 PLCS.
DRILL & TAP FOR 1/2"-13-UNC, 9/16 DEEP, DRILL THROUGH 1/4" Ø, 6" Ø B.C.D., 10 PLCS.
DRILL & TAP FOR 1/2-13-UNC, 9/16 DEEP, DRILL THROUGH 1/4" Ø, 1-1/2" Ø B.C.D., 3 PLCS.
MACHINE GROOVE FOR 3/8" O.D. TUBING (FULL DEPTH OF TUBE) ON A 4-3/4" B.C.D.
1 7/16"
PLAN
9/16"
3/8"
THERMOCOUPLE HOLE
TUBING GROOVE
SECTION

3.0 MECHANICAL AND PRELIMINARY COMMISSIONING

The initial two test runs during the period of March 20-31 using fine sand and bulk sulphide concentrate (17.55% Pb, 32.0% Zn, 0.4% Cu) obtained from Brunswick Mining and Smelting completed mechanical and preliminary plant commissioning.

The concentrate which was received wet was decanted, dried and screened through 8 mesh. The screened concentrate was blended with a fine sand (-40 mesh) to reduce the sulphur concentration from 30% to 20%, closer to that of Giant Yellowknife (18%).

During the period of March 20-23 the plant was operated on day shift using only fine sand as feed to the roaster. The feeding system on sand mode operated satisfactorily, however, modifications were made to the hopper pressure line and screw feed auger seals. A new sintered metal disc (100 micron) was added to the feed system fluidizer. Problems in operating both roasters under negative pressure stemmed from a blockage in the 1.5" condenser inlet pipe and leakage of air into the hot baghouse from the blowback system. Once these problems were rectified, mechanical commissioning was concluded.

The plant operated continuously on a 24 hour basis from March 23-31 while the BM&S bulk concentrate was fed to the first stage roaster. Initial spacial velocities at 1 ft/sec were too high to maintain a calcine bed as the 85% -400 mesh feed elutriated and largely combusted in the oxygen enriched second stage freeboard. The spacial velocity was reduced significantly to 0.75 ft/sec maintaining a bed with no combustion of sulphides in the second stage freeboard. During the run combustion was easily sustained in both stages with feed rates of 20-32 kg/h. Temperature regulation in the first and second stages was sporadic as the pressure coolant spray nozzles were prone to blockage.

Attempts to rectify the problem were unsuccessful. These measures included cooling directly in the bed as it was believed that the fine spray from the pressure nozzle was largely being carried off in the freeboard, and cooling in the plenum below the distributor plate. It was decided that either a two fluid or a coarser spray nozzle, sized for the 8" and

6" units had to be developed and tested. A coolant spray nozzle which operated in both modes was subsequently developed and tested successfully. The nozzle simply consisted of a 3/8" SS 316 Swagelock plug machined to 1/8" thickness to allow for drilling 8 x 0.015" holes on a 1/4" diameter circle. Air and water are premixed from a tee fitting in the 20" x 3/8" diameter feedpipe which extends through a coolant nozzle at an angle of 15° in the freeboard above the fluidized bed level.

4.0 PLANT COMMISSIONING

Commissioning runs using Yellowknife concentrate took place during the period of April 10 - May 5, 1989.

The bulk sulphide float concentrate from Giant Yellowknife Mines Ltd. was received on March 28. The material which was received wet, was decanted to remove excess water and dried on trays at 80°C. The dry concentrate was tumbled and screened through a 1/8" screen and stored in the original 45 gallon barrels. Five of the barrels were sampled and analyzed for Au, S, Fe and As, the results of which are given in Table 3. The average assay, 8.77% As, 18.86% Fe, 15.45% S was used to calculate the air requirements for the 1st and 2nd stage roasters. Gold averaged 1.84 oz/ton in the five head samples. A sample of the concentrate was mounted as a polished block for qualitative microscopic investigation, the results of which follow:

MINERAL COPOSITION OF THE CONCENTRATE

1. Major minerals.

   Arsenopyrite, pyrite, quartz, K-mica.

2. Accesory and trace minerals.

   Chalcopyrite, galena, native antimony, stibnite, Pb-Sb and Pb-Fe-Sb sulphosalts, dolomite, dolomitic ankerite, calcite, chlorite, Fe oxides and Fe-Ti oxides.

4.1 First Commissioning Run (April 10-12, 1989)

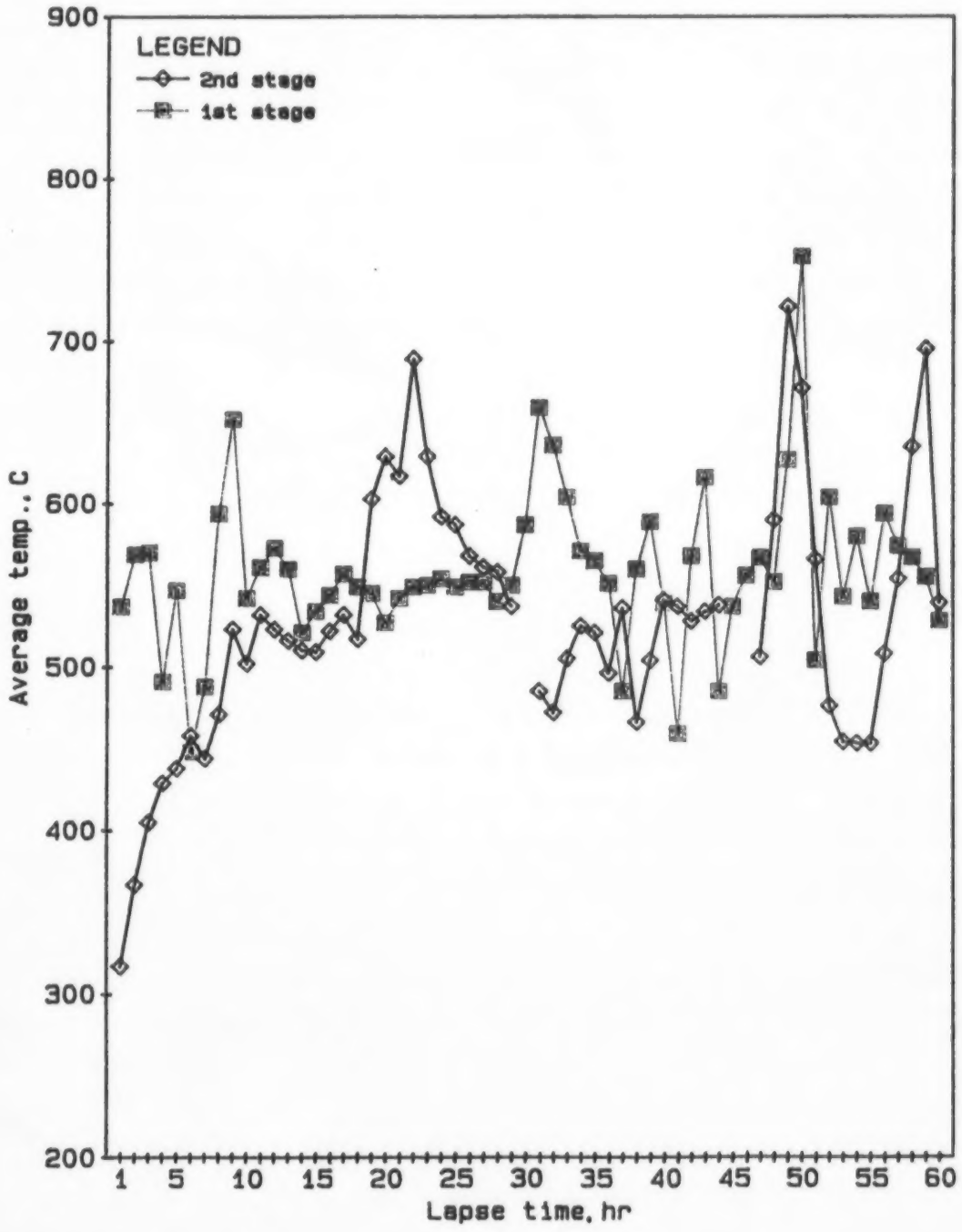
The initial commissioning run took place from April 10-12, 1989. The average feedrate during this period was 13.1 kg/hr. The calculated air requirement for this feedrate was 5.5 SCFM of air for the first stage and 1.5 SCFM for the second stage assuming 80% of stoichiometric in the first and 110% in the second. Actual total average air flows were 65% of stoichiometric at 4.49 SCFM in the first stage and 115% at 2.92 SCFM in the second stage.

TABLE 3

FEED ASSAY

Sample	% As	% Fe	% S	Au (oz/ton)
1	8.6	19.87	16.62	1.878
2	8.25	16.84	13.33	1.882
3	8.83	18.19	14.69	1.794
4	8.99	19.56	16.13	1.798
5	9.2	19.84	16.49	1.842
Average	**8.77**	**18.86**	**15.45**	**1.839**

FIGURE 5
1ST & 2ND STAGE TEMPERATURE PROFILE
Average Temp. vs Time
Date: 10/4/89 17:00



Total operating time during this initial run was 60 hours. Average temperatures in the first and second stage roaster was 557°C and 527°C. A temperature profile versus time elapsed of the two stages of roasting is given in Figure 5. The temperature profile fluctuated with a variance of ± 47°C in the first stage and is indicative of the variance in feedrate ± 4.4 kg/hr during this period. The second stage temperatures reflect the variance in bed overflow and residual sulphur from the first stage roaster.

During the operating period 500 g samples were collected every two hours from the first stage bed underflow (weepage collected from air box cleanout) and the second stage overflow. Samples were also collected from the hot and cold baghouses. All samples were monitored for colour consistency as in the Yellowknife operation. The first stage calcine was consistently black, indicative of the reducing condition and the large magnetite content and the second stage was chocolate brown indicative of oxidizing conditions and the hematite content. The air flow to the second stage roaster was increased by approximately 100% from 2.65 SCFM to 5.2 SCFM during the last few hours of operation, resulting in a red, hematite-rich calcine.

Samples of 1st and 2nd stage off gas were taken periodically into a continuous O_2 analyzer. The samples were generally taken hourly. Due to high dust loading and As_2O_3 condensate in the sample train, off gas samples were only diverted through the O_2 analyzer once per hour. A hot air sintered metal filter blowback system in the off gas sample train is recommended in any future tests. This will allow continuous sample monitoring to the gas analyzers

Gas samples taken during this period averaged 2.3% O_2 and 5.5% O_2 in first and second stages. Air contribution for the coolant nozzles equates to 2.1% O_2 (stage 1 and 2 coolant guns). The balance from the calculated 1.7% O_2 in the second stage (0% in first stage) is believed to be air leakage through ports due to negative pressures maintained in first (-0.4) and second (-3.73) stage roaster freeboards during the run.

TABLE 4

AIRFLOW REQUIREMENTS

FEED RATE :	13.1	kg/hr			
% Pressure	100.0				
FEED ASSAY :					
Fe(%)	18.9				
As	8.8				
Sb	0.6				
S	15.5				
Au(oz)	1.839				
% S in Asp	4.7				
% S in Py	10.8				
% Pyrite	20.2				
% Asp	20.5				
Rate of Asp	2.7	kg/hr			
Rate of Py	2.6	kg/hr	FLOWRATE:	1kgmol=838.2 ft3	
O2 req'd(Asp)	0.04	mol/h	171.7	SCFH Air	
O2 req'd(Py)	0.06	mol/h	242.0	SCFH Air	
		TOTAL =	413.7	SCFH Air	
		=	6.9	SCFM Air	
Air requirements:					
1st stage	331.0	SCFH =	5.5	SCFM Air	
2nd stage	91.0	SCFH =	1.5	SCFM Air	
Elemental distribution:			Fe	S	As
Pyrite		%	9.4	10.8	-
Asp		%	7.2	4.7	8.8

TABLE 5

TWO STAGE GOLD ROAST OPERATING LOG

DATE 10/04/89

TWO STAGE GOLD ROAST OPERATING LOG

TIME	FEED SCALE Kg	FEED RATE Kg/h	H2O RATE L/m	TEMPERATURES 1ST STAGE PLEN	PLATE	B1	B2	B3	AVG	FB	EXIT	OFLO	TEMPERATURES 2ND STAGE PLEN	PLATE	B1	B2	B3	AVG	FB1	FB2	EXIT	HSIN	HSO	COND IN	OUT	CSIN	CSO	1ST °H2O	PRESSURES 2ND °H2O	HSDF °H2O	HSOUT °H2O	CSIN °H2O	CSDF °H2O	CSOUT °H2O	BLOWER °H2O	AIR FLOWS FEED %	BURN SCFH	1ST %	2ND %	COND °H2O	OFF GAS 1ST % O2	2ND % O2
DAY SHIFT																																											
08:00																																											
09:00																																											
10:00																																											
11:00																																											
12:00																																											
13:00																																											
14:00	1345.5	9	0	340	423	536	536	536	536	452	393	255	----	145	317	316	317	316	----	362	362	360	360	362	202	147	135	0.7	-19.4	0	-21.6	-35.5	0.4	-36.8	-50.5	100	200	20	22	10	----	----
15:00	1333.5	12	0.1	107	324	571	570	584	588	461	402	291	----	239	386	386	387	386	----	359	378	377	306	370	218	155	137	1.6	-14.3	0	-15.9	-26.7	0.9	-27.2	-36.9	100	0	22	20	5	----	----
16:00	LOADING	----	0.15	96	325	575	574	589	589	381	404	213	----	299	405	403	404	404	----	381	382	382	370	371	241	166	144	-0.2	-8.1	0	-11.6	-26.4	1.1	-26.9	-37.8	100	0	23	20	5	----	----
17:00	1399.5	----	0	633	489	491	490	490	490	427	400	257	----	334	428	429	427	428	----	379	380	381	372	373	231	171	149	0.5	-11.8	0.6	-13.6	-27.1	0.4	-28.7	-40	100	200	25	20	5	----	----
18:00	1386	13.5	3/4 T	144	340	549	548	543	546	394	398	246	----	360	405	453	454	437	----	396	395	394	379	379	233	172	154	2.3	-8.3	0	-10.9	-21.7	1.6	-22.5	-33	80	0	25	20	5	----	----
19:00	1385.5	----	0	466	372	448	447	447	447	410	393	312	----	382	458	457	456	457	----	406	396	396	383	384	243	171	156	0.9	-12.6	0	-15.8	-32.9	-2.7	-35	-48.7	100	200	24	20	5	----	----
20:00	1370.5	15	----	619	473	474	493	495	487	462	410	309	----	401	444	444	443	443	----	436	396	392	384	384	240	172	156	-1.9	-6	0	-8.5	-18.5	1.6	-19.7	-36.2	100	200	20	20	11	----	----
21:00	1359	11.5	----	194	359	595	593	593	593	525	409	255	----	417	470	470	470	470	----	559	392	391	380	384	207	167	155	-4.3	-8.6	0	-10	-17.1	1.6	-18.3	-36.8	100	0	26	20	11	----	2.5
22:00	LOADING	----	----	115	359	653	653	648	651	529	426	216	428	----	523	522	521	522	----	502	409	395	387	387	211	157	147	-0.1	-7.6	0.1	-9.2	-16.8	1.6	-23.1	-36.7	100	0	26	20	11	----	----
23:00	1451	15	----	128	363	542	541	541	541	480	422	188	436	----	502	501	501	501	----	487	416	407	394	395	209	157	146	-1.3	-5.3	0	-7.2	-14.5	1.6	-21.6	-35.9	100	0	26	22	11	----	----
24:00	1437	14	----	134	386	561	560	559	560	485	418	275	445	----	512	571	511	531	----	413	376	401	402	405	209	161	148	-0.9	-2.7	0	-4.9	-12.6	1.6	-21.3	-37.2	100	0	26	22	11	0.9	----
01:00	1425	12	----	137	373	573	572	571	572	459	415	446	450	----	523	521	522	522	----	421	393	392	408	412	212	163	150	0.6	-2.1	0	-4.1	-11.6	1.6	-24.5	-38.6	100	0	26	22	11	----	----
02:00	1410.5	14.5	----	130	372	560	560	558	559	470	418	341	452	----	516	515	515	515	----	422	393	392	419	425	215	164	152	0.3	-2.3	0.1	-4.5	-12.8	-1.6	-13.6	-44.5	100	0	26	22	11	----	----
03:00	1396	14.5	----	129	386	580	580	580	580	488	408	282	482	----	510	509	509	509	----	410	387	387	421	426	206	163	152	-2.6	-4.2	0	-6.5	-10.5	1.6	-20.6	-44.6	100	0	23	22	14	2.5	----
04:00	1380	16	----	184	383	534	534	533	533	494	399	234	449	----	509	508	508	508	----	401	363	387	407	418	191	153	148	-3.5	-5.5	0	-7	12	1.6	-33.4	-49.3	100	0	10	22	14	----	----
05:00	1367.5	12.5	----	189	417	544	544	543	543	521	401	443	447	----	520	522	522	521	----	396	382	387	397	408	188	150	141	-4.7	-4.3	0	-6.6	-13.7	1.6	-36.3	-53.6	100	0	20	20	14	----	----
06:00	1361	6	----	185	431	587	586	586	586	522	402	317	444	----	531	531	531	531	----	404	382	388	393	400	181	144	127	-2.7	-4.3	0	-6.9	-9.6	1.6	-36.2	-49.6	100	0	20	20	14	----	----
07:00	170	LOADI	----	168	435	549	548	548	548	539	406	448	443	----	518	516	516	516	----	397	385	388	396	406	185	129	130	-0.1	-2.1	0	-4.5	-9.3	1.6	-36.1	-49.3	100	0	20	20	14	----	----

DATE 11/04/89

TWO STAGE GOLD ROAST OPERATING LOG

TIME	FEED SCALE Kg	FEED RATE Kg/h	H2O RATE L/m	TEMPERATURES 1ST STAGE PLEN	PLATE	B1	B2	B3	AVG	FB	EXIT	OFLO	TEMPERATURES 2ND STAGE PLEN	PLATE	B1	B2	B3	AVG	FB1	FB2	EXIT	HSIN	HSO	COND IN	OUT	CSIN	CSO	1ST °H2O	PRESSURES 2ND °H2O	HSDF °H2O	HSOUT °H2O	CSIN °H2O	CSDF °H2O	CSOUT °H2O	BLOWER °H2O	AIR FLOWS FEED %	BURN SCFH	1ST %	2ND %	COND °H2O	OFF GAS 1ST % O2	2ND % O2
DAY SHIFT																																											
08:00	1687.5	13.5	1/2 to	150	419	545	545	544	544	525	412	396	429	----	603	602	602	602	----	434	396	390	404	410	177	129	127	2.3	9.4	0	0.3	-3.5	1.6	-4.3	-53.1	90	0	20	20	14	0.8	----
09:00	1676	11.5	1/4	172	352	527	526	526	526	508	426	347	361	----	630	628	626	626	----	430	392	391	399	405	190	143	130	-0.4	-2.6	0	-5.6	-12	1.6	-15.3	-24.8	95	0	26	20	14	----	----
10:00	1662.5	13.5	3/8	151	341	542	541	540	541	498	419	422	292	----	613	618	617	616	----	525	383	394	397	403	190	148	136	1	-1.4	0	-5	-11.5	1.6	-14	-24.1	95	0	27	20	14	1.8	2.3
11:00	1651	11.5	3/4	159	347	549	548	548	548	448	414	391	280	----	690	688	688	688	----	429	395	394	403	406	197	150	136	-0.9	-3.6	0	-7.3	-15.1	1.6	-17.3	-30.1	95	0	27	20	14	----	----
12:00	1639	12	----	150	348	550	550	549	549	425	407	379	211	----	634	631	631	626	----	433	397	395	406	410	201	151	136	-1	-3.5	0	-6.8	-14.4	1.6	-16.7	-28.6	95	0	27	20	14	1.6	8.3
13:00	1627	12	3/4	140	349	554	554	553	553	400	401	362	186	----	592	591	591	591	----	417	394	392	407	416	198	153	139	-1.5	-3.5	0	-6	-12.7	1.6	-16.7	-29.8	95	0	29	21	14	----	----
14:00	1615	12	3/4	131	347	549	548	548	548	405	399	360	184	----	587	586	586	586	----	406	391	391	414	421	195	154	139	0.6	-1.6	0	-4.5	-10.6	1.6	-14.3	-32.4	95	0	28	21	14	4.5	7
15:00	1603	12	3/4	151	349	552	551	550	551	391	399	358	145	----	569	567	566	567	----	402	389	389	413	418	203	156	140	-1	-4.1	0	-7	-14.9	1.6	-15.9	-28.1	95	0	28	20	14	----	----
16:00	1590.5	12.5	3/4	138	349	552	551	551	551	396	398	356	129	----	559	562	561	560	----	393	387	386	406	414	201	154	140	0.5	-2.3	0	-4.7	-11.2	1.6	-14.9	-28	95	0	26	20	14	2.5	3
17:00	1579	11.5	1/2	142	342	540	539	539	539	446	414	424	118	----	556	558	558	557	----	390	386	386	404	412	194	151	137	-1.9	-3.2	0	-5.1	-10.3	1.6	-11.8	-29.7	95	0	21	21	14	----	----
18:00	1567.5	11.5	1/2	135	372	550	549	549	549	363	383	304	107	----	539	535	535	536	----	380	384	385	392	407	179	147	132	2.3	2.7	0	1.5	0.1	1.6	-5.4	-21.4	95	0	21	20	14	4.1	6
19:00	LOADING	----	----	163	383	586	586	586	586	380	384	293	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2.3	1	0	-0.1	-1.9	1.6	-2.8	-27.7	95	0	21	20	14	----	----
NIGHT SHIFT																																											
20:00	1755.5	----	----	221	431	560	559	557	558	407	396	331	248	----	487	484	483	484	----	379	384	385	417	424	191	118	99	0	-2.1	0	-4.1	-8.7	1.6	-10.6	-32.8	100	0	22	22	14	----	----
21:00	1745	10.5	----	240	437	633	636	636	635	392	402	304	300	----	472	471	470	471	----	382	386	388	410	418	186	118	96	1.4	-0.9	0	-3.2	-7.6	1.6	-8.7	-33.4	100	0	22	22	14	----	----
22:00	1734	11	----	214	405	603	603	603	603	381	399	320	341	----	504	505	504	504	----	379	386	390	418	429	184	116	101	2.3	0.6	0	-1.8	-6.2	1.6	-7.4	-37	100	0	28	22	14	----	8
23:00	1723	11	----	207	402	571	571	570	570	371	398	314	353	----	525	525	524	524	----	380	385	387	419	432	183	118	102	0.8	-1.2	0	-3	-7.4	1.6	-8.7	-44.2	100	0	21	21	13.5	----	9
24:00	1713	10	----	190	386	565	565	564	564	367	393	317	316	----	519	521	521	520	----	375	384	386	419	431	186	113	102	2.3	0.5	0	-2.1	-6.5	1.6	-7.9	-46	100	0	20	22	14	----	6.9
01:00	1703	10	----	160	357	551	550	550	550	350	365	306	251	----	497	494	494	495	----	365	382	386	421	426	192	118	101	0.3	-2	-0.1	-5.1	-12.3	1.6	-16.1	-36.3	100	0	20	20	14	----	----
02:00	1694.5	8.5	----	158	363	352	551	549	484	337	366	303	291	----	501	513	512	535	----	365	381	381	417	425	190	118	102	-0.1	-2.2	0	-4.1	-8.7	1.6	-10.1	-44.4	80	0	20	22	14	----	----
03:00	1689.5	10	----	133	359	560	559	560	559	328	377	231	328	----	467	484	484	485	----	385	379	381	406	416	187	115	100	0.1	-1.9	0	-3.5	-7.7	1.6	-9	-44.7	100	0	20	22	14	----	----
04:00	1678.5	12	----	186	380	589	589	588	588	366	361	295	355	----	503	503	503	503	----	378	384	386	407	418	180	112	100	2.3	0.3	0	-2.7	-7.2	1.6	-8.4	-47.1	100	0	22	20	14	----	----
05:00	1677	----	----	151	359	540	539	538	539	367	374	281	377	----	542	539	539	540	----	386	384	390	413	414	184	114	99	0.8	-0.9	0	-2.5	-6.4	1.6	-7.7	-48.1	100	0	24	26	14	----	----
06:00	----	----	----	656	381	489	483	443	458	369	363	163	393	----	538	536	535	536	----	389	385	384	412	409	188	111	95	-2.6	-4.2	0	-4.5	-7.6	1.6	-8.6	-49.9	30	200	22	20	14	----	----
07:00	1674.5	----	----	642	659	588	587	586	587	436	369	334	405	----	526	527	526	527	----	392	386	394	412	410	190	116	100	2.3	0.6	0	-1.3	-4.5	1.6	-7.7	-50	0	200	22	20	14	----	----

TABLE 5

TWO STAGE GOLD ROAST OPERATING LOG
(cont'd)

DATE 12/4/89

TWO STAGE GOLD ROAST OPERATING LOG

| TIME | FEED | | H2O | TEMPERATURES | | |

DATE: 10/04/89

TABLE 6 ACTUAL AIRFLOWS

TIME	FEED SCALE Kg	FEED RATE Kg/h	BURNER SCFH	FEED AIR (SCFM)	1ST STAGE (SCFM)	TOTAL AIR (SCFM)	STOICH (%)	2ND STAGE (SCFM)	STOICH (%)	N2 (SCFM)	SO2 (SCFM)	O2 AS2O3 (SCFM)	O2 Fe2O3 (SCFM)	O2 Sb2O3 (SCFM)	O2 LEFT (SCFM)	O2 OFF (%)	OFF GAS 1ST % O2	OFF GAS 2ND % O2
14:00	1345.5	9	200	1.67	2.65	4.22	61	2.93	104	5.65	0.57	0.10	0.32	0.00	0.5	8	—	—
15:00	1333.5	12	0	1.67	2.8	4.47	65	2.65	103	5.62	0.76	0.13	0.42	0.01	0.2	3	—	—
16:00	LOADING	—	0	1.67	2.91	4.58	66	2.65	108	5.71	0	0	0	0	0	0	—	—
17:00	1399.5	—	200	1.67	3.2	4.87	71	2.65	122	5.94	0	0	0	0	0	0	—	—
18:00	1396	13.5	0	1.04	3.2	4.24	61	2.65	95	5.44	0.85	0.14	0.48	0.01	0	0	—	—
19:00	1385.5	—	200	1.67	3.08	4.75	69	2.65	116	5.84	0	0	0	0	0	0	—	—
20:00	1370.5	15	200	1.67	2.55	4.22	61	2.65	94	5.42	0.95	0.16	0.53	0.01	0	0	—	—
21:00	1359	11.5	0	1.67	3.39	5.06	73	2.65	134	6.09	0.73	0.12	0.41	0.01	0.4	5	—	2.5
22:00	LOADING	—	0	1.67	3.39	5.06	73	2.65	134	6.09	0	0	0	0	0	0	—	—
23:00	1451	15	0	1.67	3.39	5.06	73	2.93	148	6.31	0.95	0.16	0.53	0.01	0	0	—	—
24:00	1437	14	0	1.67	3.39	5.06	73	3.06	156	6.43	0.88	0.15	0.50	0.01	0.2	2	0.9	—
01:00	1425	12	0	1.67	3.39	5.06	73	2.93	148	6.31	0.76	0.13	0.42	0.01	0.4	5	—	—
02:00	1410.5	14.5	0	1.67	3.39	5.06	73	2.93	148	6.31	0.91	0.15	0.51	0.01	0.1	1	—	—
03:00	1396	14.5	0	1.67	2.91	4.58	66	2.93	119	5.93	0.91	0.15	0.51	0.01	0.1	0	2.5	—
04:00	1380	16	0	1.67	1.28	2.95	43	2.93	72	4.64	1.01	0.17	0.57	0.01	0.1	0	—	—
05:00	1367.5	12.5	0	1.67	2.55	4.22	61	2.65	94	5.42	0.79	0.13	0.44	0.01	0.1	1	—	—
06:00	1361	6	0	1.67	2.55	4.22	61	2.65	94	5.42	0.38	0.06	0.21	0.00	0.8	12	—	—
07:00	1701	LOADI	0	1.67	2.55	4.22	61	2.65	94	5.42	0	0	0	0	0	0	—	—

DATE: 11/04/89

TIME	FEED SCALE Kg	FEED RATE Kg/h	BURNER SCFH	FEED AIR (SCFM)	1ST STAGE (SCFM)	TOTAL AIR (SCFM)	STOICH (%)	2ND STAGE (SCFM)	STOICH (%)	N2 (SCFM)	SO2 (SCFM)	O2 AS2O3 (SCFM)	O2 Fe2O3 (SCFM)	O2 Sb2O3 (SCFM)	O2 LEFT (SCFM)	O2 OFF (%)	OFF GAS 1ST % O2	OFF GAS 2ND % O2
08:00	1687.5	13.5	0	1.24	2.55	3.79	55	2.65	82	5.09	0.85	0.14	0.48	0.01	0	0	0.8	—
09:00	1676	11.5	0	1.43	3.39	4.82	70	2.65	120	5.90	0.73	0.12	0.41	0.01	0.3	4	—	—
10:00	1662.5	13.5	0	1.43	3.53	4.96	72	2.65	128	6.01	0.85	0.14	0.48	0.01	0.1	2	1.8	2.3
11:00	1651	11.5	0	1.43	3.53	4.96	72	2.65	128	6.01	0.73	0.12	0.41	0.01	0.3	5	—	—
12:00	1639	12	0	1.43	3.53	4.96	72	2.65	128	6.01	0.76	0.13	0.42	0.01	0.3	4	1.6	8.3
13:00	1627	12	0	1.43	3.88	5.31	77	2.8	163	6.41	0.76	0.13	0.42	0.01	0.4	5	—	—
14:00	1615	12	0	1.43	3.7	5.13	74	2.8	147	6.26	0.76	0.13	0.42	0.01	0.4	5	4.5	7
15:00	1603	12	0	1.43	3.7	5.13	74	2.65	139	6.15	0.76	0.13	0.42	0.01	0.3	4	—	—
16:00	1290.5	12.5	0	1.43	3.7	5.13	74	2.65	139	6.15	0.79	0.13	0.44	0.01	0.3	4	2.5	3
17:00	1579	11.5	0	1.43	2.67	4.10	59	2.8	95	5.45	0.73	0.12	0.41	0.01	0.2	3	—	—
18:00	1567.5	11.5	0	1.43	2.67	4.10	59	2.65	90	5.33	0.73	0.12	0.41	0.01	0.2	3	4.1	6
19:00	LOADING	—	0	1.43	2.67	4.10	59	2.65	90	5.33	0	0	0	0	0	0	—	—
20:00	1755.5	—	0	1.67	2.8	4.47	65	2.93	114	5.84	0	0	0	0	0	0	—	—
21:00	1745	10.5	0	1.67	2.8	4.47	65	2.93	114	5.84	0.66	0.11	0.37	0.01	0.4	6	—	—
22:00	1734	11	0	1.67	3.7	5.37	78	2.93	176	6.55	0.69	0.12	0.39	0.01	0.5	7	—	8
23:00	1723	11	0	1.67	2.67	4.34	63	2.8	104	5.64	0.69	0.12	0.39	0.01	0	4	—	8
24:00	1713	10	0	1.67	2.55	4.22	61	2.93	104	5.65	0.63	0.11	0.35	0.00	0	6	—	6.9
01:00	1703	10	0	1.67	2.55	4.22	61	3.77	134	6.31	0.63	0.11	0.35	0.00	0.6	8	—	—
02:00	1694.5	8.5	0	0.74	2.55	3.29	48	2.93	78	4.91	0.54	0.09	0.30	0.00	0.4	6	—	—
03:00	1689.5	10	0	1.67	2.55	4.22	61	2.93	104	5.65	0.63	0.11	0.35	0.00	0	6	—	—
04:00	1678.5	12	0	1.67	2.8	4.47	65	2.65	103	5.62	0.76	0.13	0.42	0.01	0	3	—	—
05:00	1677	—	0	1.67	3.08	4.75	69	3.49	153	6.51	0	0	0	0	0	0	—	—
06:00	—	—	200	0.35	2.8	3.15	46	2.65	68	4.58	0	0	0	0	0	0	—	—
07:00	1674.5	—	200	0.00	2.8	2.80	41	2.65	63	4.31	0	0	0	0	0	0	—	—

DATE 12/4/89

TIME	FEED SCALE Kg	FEED RATE Kg/h	BURNER SCFH	FEED AIR (SCFM)	1ST STAGE (SCFM)	TOTAL AIR (SCFM)	STOICH (%)	2ND STAGE (SCFM)	STOICH (%)	N2 (SCFM)	SO2 (SCFM)	O2 AS2O3 (SCFM)	O2 Fe2O3 (SCFM)	O2 Sb2O3 (SCFM)	O2 LEFT (SCFM)	O2 OFF (%)	OFF GAS 1ST % O2	OFF GAS 2ND % O2
08:00	1673.5	1	0	1.43	2.91	4.34	63	2.65	98	5.52	0.06	0.01	0.04	0.00	1	20	1.5	11.
09:00	1674	—	200	1.43	2.91	4.34	63	2.65	98	5.52	0	0	0	0	0	0	—	—
10:00	REPAIR	—	200	1.43	2.91	4.34	63	2.65	98	5.52	0	0	0	0	0	0	—	—
11:00	REPAIR	—	200	1.43	2.91	4.34	63	2.65	98	5.52	0	0	0	0	0	0	—	—
12:00	1624.5	21	0	1.43	2.8	4.23	61	2.65	95	5.44	1.32	0.22	0.74	0.01	0	0	2.6	8.8
13:00	1600	24.5	0	1.24	2.8	4.04	59	2.65	89	5.29	1.54	0.26	0.87	0.01	0	0	—	—
14:00	1583	17	0	1.24	2.91	4.15	60	2.65	92	5.37	1.07	0.18	0.60	0.01	0	0	2.7	0.8
15:00	1575	8	0	1.24	3.2	4.44	64	3.35	129	6.15	0.50	0.08	0.28	0.00	1	10	—	—
16:00	1572.5	5	200	1.24	2.67	3.91	57	2.8	90	5.30	0.32	0.05	0.18	0.00	1	13	—	—
17:00	1568	—	200	1.24	2.4	3.64	53	2.53	75	4.87	0	0	0	0	0	0	—	—
18:00	1565	3	200	1.24	2.55	3.79	55	2.65	82	5.09	0.19	0.03	0.11	0.00	1	16	—	—
19:00	1554.5	—	0	1.43	3.08	4.51	65	2.65	105	5.66	0	0	0	0	0	0	—	—
20:00	1555.5	—	200	1.43	2.67	4.10	59	2.65	90	5.33	0	0	0	0	0	0	—	—
21:00	1540	15.5	0	1.43	2.67	4.10	59	3.77	129	6.22	0.98	0.16	0.55	0.01	0	0	—	6
22:00	1530	20	0	1.43	2.67	4.10	59	3.77	129	6.22	1.26	0.21	0.71	0.01	0	0	—	—
23:00	1498.5	21.5	0	1.43	2.67	4.10	59	4.63	158	6.90	1.36	0.23	0.76	0.01	0	0	—	1.2
24:00	—	—	0	1.43	3.08	4.51	65	5.2	206	7.67	0	0	0	0	0	0	—	1.6
01:00	—	—	0	0.74	3.08	3.82	55	5.2	162	7.13	0	0	0	0	0	0	—	—
COUN	—	37	—	37	37	37	37	37	37	37	37	37	37	37	37	37	11	15
AVER	—	13.1	—	1.49	3.00	4.49	65.10	2.92	115	5.85	0.83	0.14	0.46	0.01	0.2	3.3	2.3	5.5
ST. DE	—	3.72	—	0.21	0.52	0.54	7.90	0.42	26.03	0.49	0.23	0.04	0.13	0.00	0	3.0	1.1	3.3
MAXIM	—	24.5	—	1.67	3.88	5.37	77.83	4.63	176	6.90	1.54	0.26	0.87	0.01	1.4	19.	4.5	11.
MINIM	—	6	—	0.74	1.28	2.95	42.74	2.65	71.70	4.64	0.38	0.06	0.21	0.00	0	0	0.8	0.8

Airflow requirement calculations, data log sheets and calculated air flow data for the runs are given in Tables 4, 5 and 6. Feed SCFM in Table 6 refers to the amount of air utilized in pneumatically transferring the feed concentrate from the feed live bottom bin/screw feeder to the roaster.

4.2 Second Commissioning Run (April 17-20, 1989)

The second commissioning run took place during the period of April 17-20, 1989 after replacing the metering screw feeder gearbox which had failed and resulted in terminating the previous week's run (April 10-12, 1989) earlier than planned. The average feedrate was 15.4 kg/hr. Calculated air requirement assuming 80% of stoichiometric O_2 in the first stage and 110% of stoichiometric in the second would be 6.5 SCFM (first stage) and 1.8 SCFM (second stage).

Actual total average airflows were 63% of stoichiometric at 5.09 SCFM in the first stage and 121% in the second stage. Total operating time during the second run was 67 hours. Average bed temperatures in the first and second stage roasters was 517°C and 509°C. Temperature profiles versus time elapsed are given in Figure 6a and 6b. Temperature variation was less than in the initial run for the first 53 hours of operation. Frequent stoppages in the last 20 hours, of which only 14 hours were feeding, excluding a 14 hour period when the plant went down due to a blower failure, resulted in large fluctuations in bed temperatures (Figure 6b).

Samples of the first stage underflow calcine were consistently black and the second stage bed overflow calcines were chocolate brown. Gas samples averaged 2.32% O_2 and 5.56% O_2 (excluding erroneously high values) in the first and second stages. As mentioned, in the initial run the high O_2 at 2.32% recorded in a reducing condition is in error due to influx of outside air and the air contribution from the coolant guns. The poor performance of the rotary blower during this period resulted in average pressures being positive at 1.26 "H_2O in the first stage and 0.170 in the second stage. The calculated O_2 was 0.8% in the second stage and <0% in the first stage. Airflow requirements calculations, data log sheets and calculated air flow data are given in Tables 7, 8 and 9.

FIGURE 6A
1ST & 2ND STAGE TEMPERATURE PROFILE
Average Temp. vs Time
Date: 17/4/89 14:00

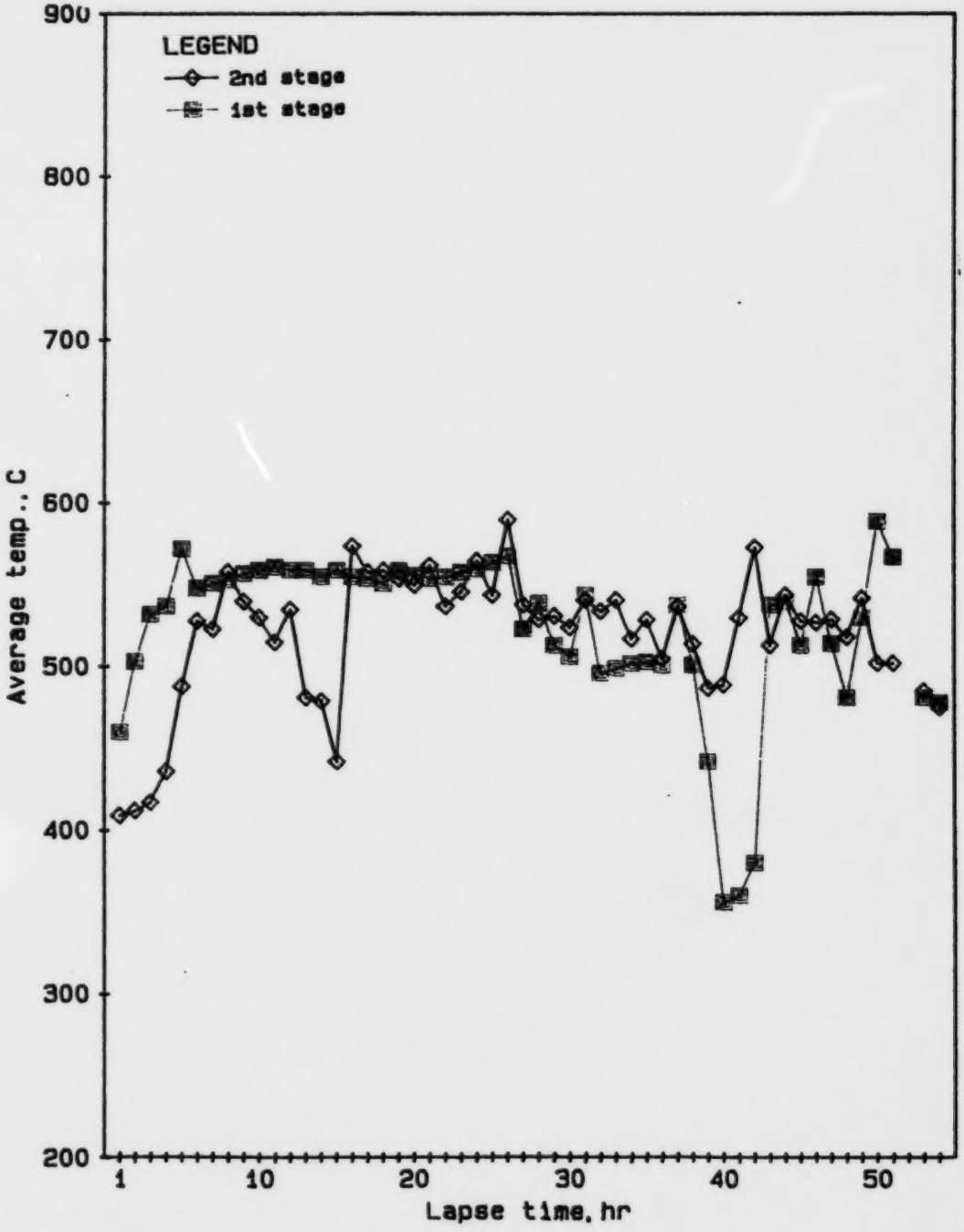


FIGURE 6B
1ST & 2ND STAGE TEMPERATURE PROFILE
Average Temp. vs Time
Date: 17/4/89 14:00

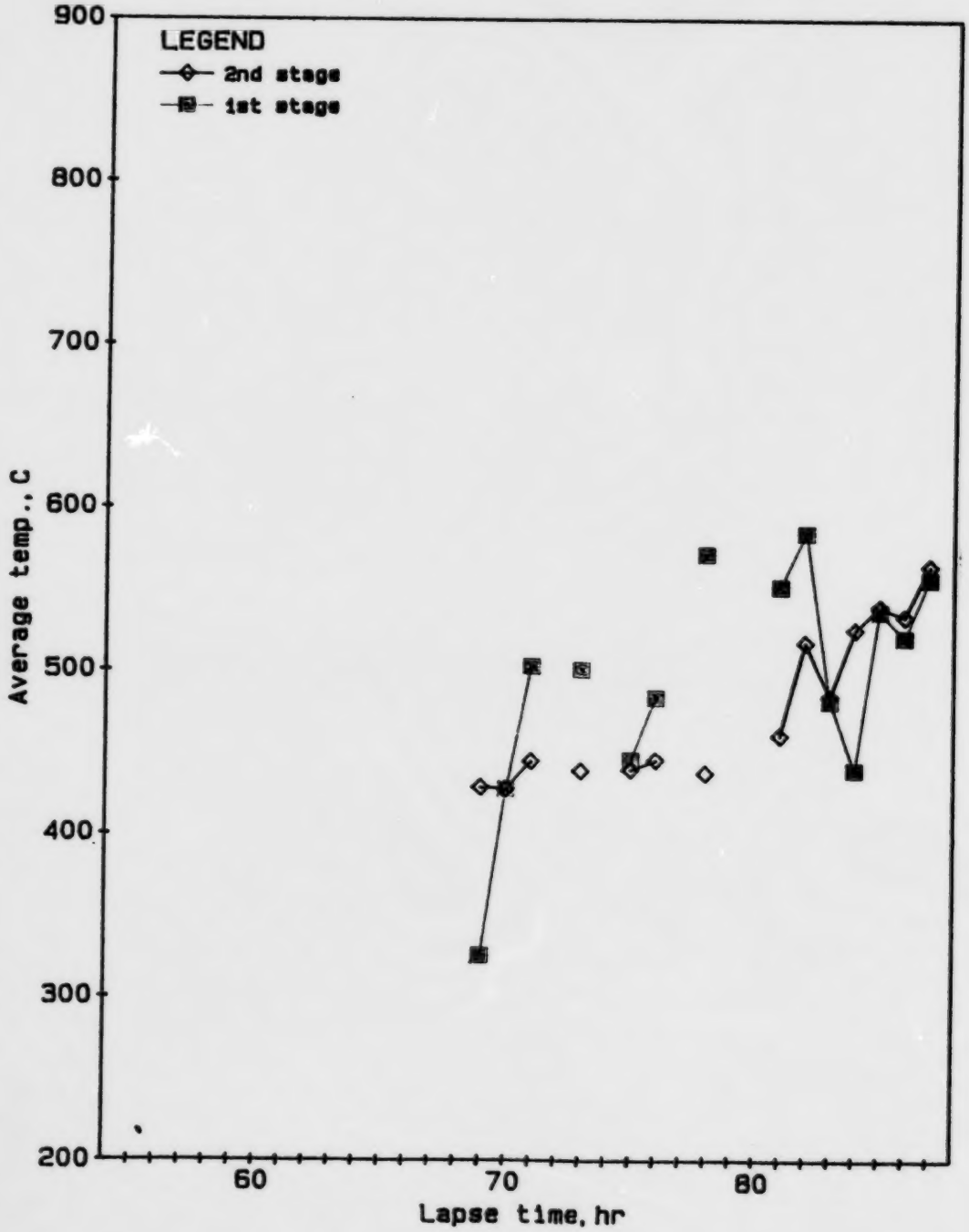


TABLE 7

AIRFLOW REQUIREMENTS

FEED RATE :	15.4	kg/hr				
% Pressure	100.0					
FEED ASSAY :						
Fe(%)	18.9					
As	8.8					
Sb	0.6					
S	15.5					
Au(oz)	1.839					
% S in Asp	4.7					
% S in Py	10.8					
% Pyrite	20.2					
% Asp	20.5					
Rate of Asp	3.1	kg/hr				
Rate of Py	3.1	kg/hr	FLOWRATE:	1kgmol=838.2 ft3		
O2 req'd(Asp)	0.05	mol/h		201.8	SCFH Air	
O2 req'd(Py)	0.07	mol/h		284.5	SCFH Air	
		TOTAL =		486.3	SCFH Air	
		=		8.1	SCFM Air	
Air requirements:						
1st stage	389.1	SCFH =		6.5	SCFM Air	
2nd stage	107.0	SCFH =		1.8	SCFM Air	
Elemental distribution:				Fe	S	As
Pyrite		%		9.4	10.8	–
Asp		%		7.2	4.7	8.8

TABLE 8

TWO STAGE GOLD ROAST OPERATING LOG

DATE 17/04/89

TWO STAGE GOLD ROAST OPERATING LOG

TIME	FEED		H2O	TEMPERATURES																												PRESSURES							AIR FLOWS						OFF GAS	
	SCALE	RATE	RATE	1ST STAGE						2ND STAGE												HGH	COND		CBH		1ST	2ND	HSDF	HSOUT	CBH	CSDF	CSOUT	BLOWER	FEED	BURN	1ST	2ND	COND	1ST	2ND
	Kg	Kg/h	L/m	PLEN	PLATE	B1	B2	B3	AVG	FB	EXIT	OFLO	PLEN	PLATE	B1	B2	B3	AVG	FB1	FB2	EXIT	HSIN	HSO	IN	OUT	CBIN	CBO	"H2O	"H2O	"H2O	"H2O	"H2O	"H2O	"H2O	"H2O	%	SCFH	%	%	"H2O	% OE	% OE
DAY SHIFT																																												
08:00																																												
09:00																																												
10:00																																												
11:00																																												
12:00																																												
13:00																																												
14:00	---	---	---	653	502	460	459	458	459	418	377	109	226	---	355	423	446	408	---	356	376	377	410	406	285	62	58	-0.1	-1.5	0	-1.9	-4.4	1	-4.6	-11.5	0	200	0	18	0	---	---
15:00	---	---	---	662	536	503	503	501	502	433	379	121	251	---	361	428	445	411	---	358	377	377	404	402	288	66	61	0.1	-1.5	0	-1.9	-4.3	1.2	-4.5	-11.3	0	200	0	18	0	---	---
16:00	---	---	---	666	555	532	532	530	531	446	390	127	276	---	372	435	443	416	---	359	374	376	396	397	289	69	64	0.5	-1.5	0	-1.9	-4.3	1.3	-4.5	-11.3	0	200	0	18	0	---	---
17:00	1458.5	(17:30)	---	666	562	539	537	535	536	457	380	182	297	---	427	435	434	435	---	367	373	376	393	394	292	72	67	0.9	-0.8	0	-1.4	-4.1	1.4	-4.3	-11.2	0	200	0	18	0	---	---
18:00	1448	17	---	202	427	572	572	570	571	442	401	319	331	---	483	489	489	487	---	400	382	383	391	404	271	144	123	2.3	1.2	0	-0.2	-1	-1.2	-4.3	-20.4	90	0	28	26	14	2.6	7
19:00	1931.5	16.5	---	152	377	548	547	547	547	371	391	311	352	---	528	528	527	527	---	388	390	384	396	397	220	130	121	2.3	0.8	0	-0.4	-3.1	1.6	-5.1	-20.1	90	0	22	18	14	2.3	9
20:00	1418	15.5	15/	158	360	551	550	550	550	376	387	329	369	---	522	523	523	522	---	381	377	382	377	401	199	120	112	2.3	2	0	0.2	-3.1	1.6	-4.1	-19.9	85	0	23	21	14	---	---
21:00	1400	16	1	162	354	553	552	552	552	411	385	375	384	---	557	557	557	557	---	412	380	379	387	403	193	111	103	1.9	1.4	0	0	-3.9	1.6	-6.2	-20.6	85	0	23	20	14	2.4	5.6
22:00	1384	16	1	166	352	557	556	556	556	453	399	397	393	---	536	541	540	539	---	388	379	380	399	395	190	112	102	2.3	0.6	0	-0.6	-4	1.3	-4.9	-18.6	85	0	23	20	14	---	---
23:00	1367	17	1	172	345	559	558	558	558	486	397	405	398	---	542	526	519	529	---	412	383	386	399	393	189	112	102	1.6	-0.2	0	-1	-3.8	1.6	-7	-22.3	85	0	23	20	14	1.4	4.8
24:00	1351	18	1	170	340	561	560	560	560	497	393	404	405	---	510	517	517	514	---	388	376	382	396	397	178	110	103	1.6	0.9	0	0.2	-2.9	1.6	-4.6	-23.7	85	0	23	20	14	---	---
01:00	1334	17	1	170	342	558	558	558	558	477	397	400	406	---	534	534	534	534	---	397	380	381	399	393	182	110	101	1.5	0.8	0	-0.4	-3.7	0.2	-7.1	-18.5	85	0	23	20	14	1.2	4.2
02:00	1319	15	1	162	349	559	558	558	558	456	398	394	403	---	542	549	549	480	---	380	374	382	373	395	170	104	97	1.5	0.8	0.1	-0.2	-3.4	1.1	-9	-21	85	0	23	20	14	---	---
03:00	1302.5	16.5	1	167	340	555	556	554	554	459	395	406	406	---	534	539	362	478	---	384	374	380	363	390	166	99	91	1.4	0.5	0.1	-0.2	-3.1	0.4	-8.9	-18	85	0	22	20	14	1.8	4.4
04:00	LOADING	---	1	110	327	559	559	558	558	511	417	428	418	---	432	446	448	441	---	380	379	382	394	402	188	102	91	2	2.4	-0.1	0	-3.7	1.2	-8.7	-18.9	85	0	46	20	10	---	---
05:00	1438	---	2	270	334	555	554	554	554	481	391	396	417	---	579	576	574	573	---	449	382	382	399	397	191	110	96	0.8	-3.5	0.8	-1	-4.6	1.1	-7.8	-20.6	85	0	39	22	10	2.2	1.4
06:00	1421	17	1	162	333	554	553	553	553	459	399	406	423	---	568	556	557	557	---	430	390	387	399	396	194	112	99	1.3	-1	0.4	-0.5	-4.7	1.6	-8.4	-20	85	0	22	22	10	---	---
07:00	1403.5	17.5	1	186	321	561	561	560	560	455	396	417	429	---	565	560	559	558	---	422	388	389	397	396	191	110	100	1.1	-2.1	0.6	-0.5	-5.5	1.6	-8.9	-27.5	85	0	22	22	10	1.6	2.4

DATE 18/04/89

TWO STAGE GOLD ROAST OPERATING LOG

TIME	FEED		H2O	TEMPERATURES																												PRESSURES							AIR FLOWS						OFF GAS	
	SCALE	RATE	RATE	1ST STAGE						2ND STAGE												HGH	COND		CBH		1ST	2ND	HSDF	HSOUT	CBH	CSDF	CSOUT	BLOWER	FEED	BURN	1ST	2ND	COND	1ST	2ND
	Kg	Kg/h	L/m	PLEN	PLATE	B1	B2	B3	AVG	FB	EXIT	OFLO	PLEN	PLATE	B1	B2	B3	AVG	FB1	FB2	EXIT	HSIN	HSO	IN	OUT	CBIN	CBO	"H2O	"H2O	"H2O	"H2O	"H2O	"H2O	"H2O	"H2O	%	SCFH	%	%	"H2O	% OE	% OE
DAY SHIFT																																												
08:00	1384.5	19	---	121	315	559	558	558	558	463	397	436	434	---	562	554	553	553	---	410	389	388	387	396	195	112	101	1.7	1.2	0.1	-0.2	-4.3	1.6	-8.3	-24	80	0	30	23	10	---	2.6
09:00	1367.5	18	---	171	323	556	556	555	555	431	402	399	438	---	548	551	550	549	---	434	393	389	388	393	195	114	105	1.8	2.4	-0.2	0	-3.4	1.6	-14	-27.2	80	0	30	23	10	---	2.7
10:00	1351.5	16	---	127	322	554	553	552	553	410	398	386	440	---	561	562	561	561	---	462	398	393	388	390	196	119	108	1.6	2.1	-0.1	0	-2.8	1.6	-4.5	-29.9	80	0	30	22	10	---	3.6
11:00	1333.5	18	---	150	325	555	554	554	554	423	400	396	442	---	537	536	536	536	---	477	415	404	396	402	208	126	103	0.7	-7.6	1.9	-1.9	-16.3	1.3	-18.9	-33.6	80	0	30	22	10	---	3.6
12:00	1316	17.5	---	133	328	558	557	557	557	415	397	417	441	---	537	549	549	549	---	417	400	400	396	404	199	128	117	1.5	0.2	0.2	-0.3	-5.4	0.4	-13.6	-22.9	80	0	30	22	10	---	2.6
13:00	1298.5	17.5	---	125	324	560	559	558	559	406	395	428	441	---	566	563	563	564	---	400	387	390	394	400	199	121	115	1.8	4.5	-0.6	0.3	-1.1	0.5	-12.9	-22.4	80	0	30	22	10	---	3.1
14:00	1282.5	16	---	122	329	564	563	563	563	401	394	401	450	---	544	543	543	543	---	385	383	386	396	405	199	120	111	1.7	3	-0.3	0.2	-1.6	1.6	-4.3	-27.2	80	0	30	27	10	---	3.3
15:00	LOADING	---	---	118	325	568	567	566	567	404	394	401	460	---	590	589	588	589	---	381	377	379	394	401	199	119	113	1.6	2.7	-0.3	0.1	-1.7	1.6	-17.7	29.8	85	0	30	26	10	---	5.2
16:00	1532	---	---	145	335	567	578	421	522	400	357	291	423	---	536	536	537	537	---	353	369	377	402	395	226	106	96	1.5	0.2	0	-0.1	-0.7	0	-0.7	1.5	80	0	35	22	10	---	9
17:00	1527	10	---	76	320	540	536	537	538	350	381	306	430	---	528	529	526	528	---	362	370	374	395	403	220	120	104	1.5	0.6	0.2	0	-5	1.6	-7.5	-40.2	80	0	35	22	10	---	9.4
18:00	1509.5	17.5	---	76	303	513	513	512	512	357	376	316	423	---	530	530	530	530	---	366	370	374	393	402	210	116	100	1.4	-0.2	0.3	-0.4	-6.3	1.6	-7.3	-39.9	80	0	36	22	10	---	8.6
19:00	1492	17.5	---	100	299	506	505	504	505	357	378	343	435	---	525	523	522	523	---	370	372	374	391	399	211	118	103	1.5	1.4	0	-0.2	-5.2	1.6	-26.1	-45.3	80	0	35	22	10	---	7.8
NIGHT SHIFT																																												
20:00	1475	17	---	83	298	545	543	541	543	377	381	361	437	---	541	540	540	540	---	362	369	372	392	396	211	130	98	1.7	4.7	-0.2	-0.4	-0.4	1.6	-11.5	-35.5	80	0	35	22	11	---	4.2
21:00	1458.5	16.5	---	89	290	496	496	495	495	344	378	331	436	---	532	535	534	533	---	356	367	370	384	390	208	132	106	1.5	-0.3	0.2	-0.5	-4.7	1.6	-8.5	-33.1	80	0	35	22	11	---	---
22:00	1432	---	---	73	268	499	498	498	498	340	378	336	434	---	540	540	540	540	---	356	367	370	381	388	199	122	103	1.4	0.1	0.2	-0.3	-5.9	1.6	-7.1	-39.2	80	0	35	21	11	---	5.6
23:00	1415	17	---	66	285	502	501	500	501	335	375	316	434	---	512	518	518	516	---	360	368	373	381	388	200	124	106	1.4	0.3	0.2	-0.3	-5.7	1.6	-6.8	-45.4	80	0	35	21	11	---	---
24:00	1399.5	15.5	---	74	288	503	502	502	502	335	375	332	433	---	527	529	529	528	---	366	371	374	390	395	197	124	107	1.4	1.6	0	-0.3	-5.4	1.6	-7.3	-34.2	80	0	36	20	11	---	5.3
01:00	1383.5	16	---	65	281	501	501	500	500	342	371	331	433	---	507	503	502	504	---	366	370	373	378	385	194	123	105	1.4	0.2	0.2	-0.4	-6.3	1.6	-7.6	-37.2	80	0	35	20	11	---	7
02:00	1370	4.5	---	72.	301	541	539	533	537	322	368	306	431	---	536	536	536	536	---	357	366	370	379	384	202	122	106	1.5	2.2	-0.2	-0.1	-6.9	1.6	-7.9	-29.8	80	0	36	20	11	---	---
03:00	1377	2	---	66	302	511	511	480	500	333	356	256	426	---	514	513	513	513	---	348	362	367	380	381	196	119	98	0.9	-2.5	-0.7	-0.8	-9.8	1.6	-10	-36.9	80	0	35	20	11	---	15
04:00	1572.5	---	---	70	290	445	445	434	441	332	360	178	425	---	496	481	480	486	---	360	365	369	375	380	191	114	90	0.1	-4.6	1.1	-1.2	-10.8	1.6	-11.9	-41.8	80	0	35	20	11	---	---
05:00	1570.5	2	---	341	386	357	356	354	355	319	359	232	425	---	502	481	481	488	---	362	368	369	376	381	196	116	93	1.2	-1.4	0.5	-0.7	-9.7	1.6	-11	-43.5	80	200	36	20	11	---	---
06:00	1557	13.5	---	372	464	360	360	359	359	327	367	230	421	---	534	532	531	529	---	368	370	371	374	382	198	120	98	1.5	-0.6	0.4	-0.6	-8.8	1.6	-8.8	-48.6	80	160	36	20	11	---	---
07:00	1544	13	---	670	495	399	379	370	379	343	369	218	421	---	572	572	572	572	---	395	375	376	378	382	197	120	99	1.4	-1.2	0.6	-0.6	-7.6	1.6	-8.6	-61.4	80	200	10	22	11	---	11

DATE 19/04/89

TABLE 8 TWO STAGE GOLD ROAST OPERATING LOG (cont'd)

TIME	FEED SCALE Kg	FEED RATE Kg/h	H2O RATE L/m	1ST STAGE TEMPERATURES PLEN	PLATE	B1	B2	B3	AVG	F8	EXIT	OFLO	2ND STAGE TEMPERATURES PLEN	PLATE	B1	B2	B3	AVG	FB1	FB2	EXIT	HBH	HBO	COND IN	COND OUT	CBH CBH	CBO	1ST PRESSURES °H2O	2ND °H2O	HBDF °H2O	HBOUT °H2O	CBH °H2O	CBDF °H2O	CBOUT °H2O	BLOWER °H2O	AIR FLOWS FEED %	BURN SCFH	1ST %	2ND %	COND °H2O	OFF GAS 1ST %	2ND %
																								DAY SHIFT																		
08:00	1542	2	----	244	480	541	540	532	537	369	361	268	426	----	513	513	512	512	----	362	370	374	374	381	197	118	102	1.4	-1.2	0.4	-0.6	-7.6	1.6	-8.5	-52.2	80	0	35	22	10	----	7.6
09:00	1520	22	----	127	368	540	539	536	539	362	367	303	426	----	545	543	543	543	----	369	371	373	377	365	194	117	105	1.4	1.9	-0.1	0	-5.5	1.6	-7	-55.3	80	0	35	22	10	----	4.6
10:00	1493.5	26.5	----	113	342	513	512	512	512	365	368	372	433	----	528	526	527	527	----	378	373	373	376	363	199	121	106	1.4	1.7	-0.1	-0.1	4.1	1.6	-5.4	-49.5	----	0	35	22	10	----	6
11:00	1480	15.5	----	162	338	555	554	553	554	344	361	316	438	----	526	527	525	526	----	361	372	376	380	364	201	121	109	1.4	1.3	0	-0.1	-4	1.6	-5.4	-51.3	80	0	35	22	10	----	----
12:00	1491.5	11.5	----	157	356	561	561	419	513	362	367	266	401	----	553	536	495	528	----	346	361	345	339	311	161	88	69	1.8	0.7	-0.1	0	0	-0.3	0	-0.1	0	0	0	0	0	----	----
13:00	1491.5	0	----	149	332	546	547	348	480	411	348	206	370	----	538	523	491	517	----	341	349	343	343	265	174	79	73	1.4	-0.1	0	-0.1	-0.8	-0.4	-1.3	-1.5	0	0	0	0	0	----	----
14:00	1490.5	1	----	83	309	531	530	528	529	396	352	171	352	----	543	540	542	541	----	222	368	372	373	343	237	86	72	1.7	0.4	0	-0.1	-2	1.6	-3	-39.8	80	0	35	22	10	----	16
15:00	1489	1.5	----	137	346	593	625	547	588	383	373	226	371	----	517	511	475	501	----	337	366	361	362	377	213	127	107	1.4	-1.4	0.3	-0.5	-2.7	0.7	-3.7	-52.2	80	0	0	10	14	----	----
16:00	1477.5	0	----	121	347	579	573	546	566	368	370	206	356	----	502	496	503	501	----	342	366	362	360	379	181	113	99	1.4	-1.4	0.3	-0.5	-2.6	0.5	-3.6	-53.9	90	0	0	10	14	----	----
17:00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
18:00	1463.5	0	----	128	308	504	494	444	480	418	348	117	307	----	485	484	485	484	----	346	368	767	392	383	153	91	79	1.4	-2.2	0.4	-0.7	-3.1	0.4	-4	-55.5	90	0	0	10	14	----	----
19:00	1462.5	1	----	691	495	478	477	476	477	412	377	233	299	----	476	472	476	474	----	351	373	374	392	397	163	97	84	1.4	-0.3	0.1	-0.3	-2.4	0.4	-3.4	-55.1	40	80	0	11	14	----	----
																								NIGHT SHIFT																		
20:00																																											
21:00																																											
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06:00																																											
07:00																																											

DATE 20/04/89

TWO STAGE GOLD ROAST OPERATING LOG

TIME	FEED SCALE Kg	FEED RATE Kg/h	H2O RATE L/m	1ST STAGE TEMPERATURES PLEN	PLATE	B1	B2	B3	AVG	F8	EXIT	OFLO	2ND STAGE TEMPERATURES PLEN	PLATE	B1	B2	B3	AVG	FB1	FB2	EXIT	HBH	HBO	COND IN	COND OUT	CBH CBH	CBO	1ST PRESSURES °H2O	2ND °H2O	HBDF °H2O	HBOUT °H2O	CBH °H2O	CBDF °H2O	CBOUT °H2O	BLOWER °H2O	AIR FLOWS FEED %	BURN SCFH	1ST %	2ND %	COND °H2O	OFF GAS 1ST %	2ND %
																								DAY SHIFT																		
08:00																																											
09:00																																											
10:00	1440.5	0	----	496	272	323	323	329	325	400	356	94	194	----	400	442	443	428	----	346	374	390	388	388	161	95	88	-8.2	-11.2	1.9	-2.4	-17.5	1	-18.6	-34.1	40	200	0	0	14	----	----
11:00	1440.5	0	----	579	481	429	429	424	427	412	378	215	188	----	400	448	436	427	----	367	373	372	390	391	158	100	90	1.6	0.6	0	-0.1	-1.7	0.6	-2.5	-31.5	40	200	0	0	14	----	----
12:00	1440.5	0	----	717	566	505	505	497	502	439	384	266	186	----	436	448	449	444	----	380	371	372	387	387	157	98	88	1.5	0.8	-0.1	0	-1.2	0.7	-2	-28.3	40	200	0	0	14	----	----
13:00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
14:00	1430	0	----	97	354	500	500	501	500	462	378	227	167	----	438	436	440	438	----	373	388	384	372	377	148	94	86	1.5	1.8	-0.2	0.1	-1.1	0.9	-2.1	-39.3	----	0	0	0	14	----	----
15:00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
16:00	1412	0	----	631	420	445	444	448	445	445	374	231	168	----	444	442	432	439	----	389	389	378	384	378	148	88	77	1.4	0.8	-0.1	0	-1.5	1	-2.3	-40	30	200	0	0	14	----	----
17:00	1412	0	----	728	556	486	485	480	483	449	390	283	169	----	433	446	457	445	----	366	370	372	383	388	158	96	85	1.4	0.3	0	-0.1	-1.8	1.1	-2.8	-41	30	200	0	0	16	----	----
18:00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
19:00	1412	0	----	512	591	574	573	566	571	478	399	292	264	----	438	436	437	437	----	361	373	374	384	387	160	104	87	1.4	0.2	0.1	-0.3	-4.1	1.1	-6	-18.1	90	200	0	20	10	----	----
																								NIGHT SHIFT																		
20:00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
21:00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
22:00	1402	----	----	235	490	553	553	548	551	488	402	234	258	----	486	480	480	480	----	377	370	371	374	378	178	102	85	1.3	-0.6	0.2	-0.4	-4.4	0.8	-5.2	-18	80	0	35	20	10	----	----
23:00	1386	16	----	106	389	588	596	580	594	490	450	353	310	----	517	517	517	517	----	425	386	384	383	388	184	109	96	1.5	3	-0.3	0.2	-3.3	1.6	-4.4	-19.2	80	0	35	20	10	----	----
24:00	1381	5	----	123	347	483	483	478	481	425	391	268	236	----	485	484	484	484	----	376	375	379	382	383	184	110	98	1.4	0.1	0.1	-0.4	-3.8	1.6	-4.3	-19.6	80	0	35	22	10	----	----
01:00	1365	16	----	660	603	440	440	439	439	410	393	300	265	----	526	525	525	525	----	385	375	379	374	388	186	109	98	1.7	2.6	-0.3	0.2	-2.5	1.6	-3.4	-22	80	180	10	22	10	----	----
02:00	1356	9	----	236	485	536	536	536	536	437	399	322	300	----	541	539	539	539	----	372	374	380	378	388	192	114	106	1.6	2.6	-0.2	0.2	-1.6	1.6	-4.7	-23.3	80	0	35	22	10	----	----
03:00	1338	18	----	96	363	521	520	519	520	385	401	338	394	----	535	534	532	533	----	386	371	376	381	381	200	122	110	1.6	2.7	-0.2	0.1	-2.6	1.6	-4.3	-19.6	80	0	35	22	10	----	----
04:00	1332	6	----	110	345	557	556	556	556	375	363	307	402	----	365	564	563	564	----	362	364	370	377	383	194	121	109	1.4	0.3	0	-0.2	-2.6	1.6	-4	-19.1	80	0	20	20	10	----	----
05:00																																											
06:00																																											
07:00																																											
COUN	----	56	----	67	67	67	67	67	67	67	67	67	67	----	67	67	67	67	----	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	66	67	67	67	67	8	30
AVG	----	11.2	----	238	373.7	521	521	509	517	407	363	304.	372	----	509	513	506	509	----	374	374	382	383	387	197	109	96.	1.26	0.170	0.11	-0.39	-4.39	1.204	-6.91	-29.511	88.	41.79	22.	18.	10.41	2.7	6.1
ST.DE	----	7.56	----	207	84.07	55.	56.	60.	54.	50.	16.	88.1	81.	----	82.	42.	48.	44.	----	34.	16.	48.	11.	18.	30.	18.	12.	1.37	2.416	0.42	0.670	3.349	0.596	4.582	16.3459	27.	79.22	14.	7.6	3.673	4.3	2.8
MAXI	----	26.5	----	726	591	593	625	580	586	511	450	436	460	----	590	589	588	589	----	477	416	767	410	406	292	144	123	2.3	4.7	1.9	0.2	4.1	1.6	0	29.8	90	200	40	35	14	15	16
MINI	----	0	----	65	272	323	323	329	325	315	348	94	167	----	365	423	349	406	----	222	345	343	339	365	145	62	58	-8.3	-11.2	-0.7	-2.4	-17.5	-1.2	-28.1	-67.2	0	0	0	0	0	1.2	1.4

TABLE 9

ACTUAL AIRFLOWS

DATE 17/04/89

TIME	FEED SCALE	FEED RATE	BURNER	FEED AIR	1ST STAGE AIR	TOTAL AIR	STOICH	2ND STAGE	STOICH	N2	SO2	O2 As2O3	O2 Fe2O3	O2 Sb2O3	O2 LEFT	O2 OFF	OFF GAS 1ST	OFF GAS 2ND
	Kg	Kg/h	SCFH	(SCFH)	(SCFH)	(SCFH)	(%)	(SCFH)	(%)	(SCFH)	(SCFH)	(SCFH)	(SCFH)	(SCFH)	(SCFH)	(%)	% O2	% O2
14:00	----	----	200	0.00	0.00	0.00	0	2.4	30	1.90	0	0	0	0	0	0	----	----
15:00	----	----	200	0.00	0.00	0.00	0	2.4	30	1.90	0	0	0	0	0	0	----	----
16:00	----	----	200	0.00	0.00	0.00	0	2.4	30	1.90	0	0	0	0	0	0	----	----
17:00	1456.5	(17:30)	200	0.00	0.00	0.00	0	2.4	30	1.90	0	0	0	0	0	0	----	----
18:00	1448	17	0	1.24	3.7	4.94	61	3.49	110	6.66	1.07	0.18	0.60	0.01	0	0	2.5	7
19:00	1931.5	16.5	0	1.24	2.8	4.04	50	2.4	59	5.09	1.04	0.18	0.58	0.01	0	0	2.3	9
20:00	1416	15.5	0	1.13	2.91	4.04	50	2.8	69	5.40	0.98	0.16	0.55	0.01	0	0	----	----
21:00	1400	16	0	1.13	2.91	4.04	50	2.65	65	5.29	1.01	0.17	0.57	0.01	0	0	3.4	5.6
22:00	1384	16	0	1.13	2.91	4.04	50	2.65	65	5.29	1.01	0.17	0.57	0.01	0	0	----	----
23:00	1367	17	0	1.13	2.91	4.04	50	2.65	65	5.29	1.07	0.18	0.60	0.01	0	0	1.4	4.8
24:00	1351	16	0	1.13	2.91	4.04	50	2.65	65	5.29	1.01	0.17	0.57	0.01	0	0	----	----
01:00	1334	17	0	1.13	2.91	4.04	50	2.65	65	5.29	1.07	0.18	0.60	0.01	0	0	1.2	4.2
02:00	1319	15	0	1.13	2.91	4.04	50	2.65	65	5.29	0.95	0.16	0.53	0.01	0	0	----	----
03:00	1302.5	16.5	0	1.13	2.91	4.04	50	2.65	65	5.29	1.04	0.18	0.58	0.01	0	0	1.8	4.4
04:00	LOADING	----	0	1.13	5.9	7.03	87	2.65	245	7.65	0	0	0	0	0	0	----	----
05:00	1438	----	0	1.13	2.55	3.68	45	2.93	66	5.22	0	0	0	0	0	0	2.2	1.4
06:00	1421	17	0	1.13	2.8	3.93	48	2.93	70	5.42	1.07	0.18	0.60	0.01	0	0	----	----
07:00	1403.5	17.5	0	1.13	2.8	3.93	48	2.93	70	5.42	1.10	0.19	0.62	0.01	0	0	15	2.4

DATE 18/04/89

TIME	FEED SCALE	FEED RATE	BURNER	FEED AIR	1ST STAGE AIR	TOTAL AIR	STOICH	2ND STAGE	STOICH	N2	SO2	O2 As2O3	O2 Fe2O3	O2 Sb2O3	O2 LEFT	O2 OFF	OFF GAS 1ST	OFF GAS 2ND
	Kg	Kg/h	SCFH	(SCFH)	(SCFH)	(SCFH)	(%)	(SCFH)	(%)	(SCFH)	(SCFH)	(SCFH)	(SCFH)	(SCFH)	(SCFH)	(%)	% O2	% O2
08:00	1384.5	19	0	1.04	4.05	5.09	63	3.08	102	6.45	1.20	0.20	0.67	0.01	0	0	----	2.5
09:00	1367.5	18	0	1.04	4.05	5.09	63	3.08	102	6.45	1.13	0.19	0.64	0.01	0	0	----	2.7
10:00	1351.5	16	0	1.04	4.05	5.09	63	3.08	102	6.45	1.01	0.17	0.57	0.01	0	0	----	3.5
11:00	1333.5	18	0	1.04	4.05	5.09	63	2.93	97	6.34	1.13	0.19	0.64	0.01	0	0	----	3.6
12:00	1316	17.5	0	1.04	4.05	5.09	63	2.93	97	6.34	1.10	0.19	0.62	0.01	0	0	----	2.5
13:00	1298.5	17.5	0	1.04	4.05	5.09	63	2.93	97	6.34	1.10	0.19	0.62	0.01	0	0	----	3.1
14:00	1282.5	16	0	1.04	4.05	5.09	63	3.63	120	6.89	1.01	0.17	0.57	0.01	0.1	1	----	3.3
15:00	LOADING	----	0	1.13	4.05	5.18	64	3.77	129	7.07	0	0	0	0	0	0	----	6.2
16:00	1532	----	0	1.04	4.89	5.93	73	2.93	134	7.00	0	0	0	0	0	0	----	9
17:00	1527	10	0	1.04	4.89	5.93	73	2.93	134	7.00	0.63	0.11	0.35	0.00	0.8	9	----	9.4
18:00	1509.5	17.5	0	1.04	4.89	5.93	73	2.93	134	7.00	1.10	0.19	0.62	0.01	0	0	----	8.6
19:00	1492	17.5	0	1.04	4.89	5.93	73	2.93	134	7.00	1.10	0.19	0.62	0.01	0	0	----	7.8
20:00	1475	17	0	1.04	4.89	5.93	73	2.93	134	7.00	1.07	0.18	0.60	0.01	0	0	----	4.2
21:00	1458.5	16.5	0	1.04	4.89	5.93	73	2.93	134	7.00	1.04	0.18	0.58	0.01	0.1	1	----	----
22:00	1432	----	0	1.04	4.89	5.93	73	2.8	128	6.90	0	0	0	0	0	0	----	5.6
23:00	1415	17	0	1.04	4.89	5.93	73	2.8	128	6.90	1.07	0.18	0.60	0.01	0	0	----	----
24:00	1399.5	15.5	0	1.04	4.89	5.93	73	2.65	122	6.78	0.98	0.16	0.55	0.01	0.1	1	----	5.3
01:00	1383.5	16	0	1.04	4.89	5.93	73	2.65	122	6.78	1.01	0.17	0.57	0.01	0	1	----	7
02:00	1379	4.5	0	1.04	4.89	5.93	73	2.65	122	6.78	0.28	0.05	0.16	0.00	1.3	16	----	----
03:00	1377	2	0	1.04	4.89	5.93	73	2.65	122	6.78	0.13	0.02	0.07	0.00	1.6	19	----	15
04:00	1572.5	----	0	1.04	4.89	5.93	73	2.65	122	6.78	0	0	0	0	0	0	----	----
05:00	1570.5	2	200	1.04	4.89	5.93	73	2.65	122	6.78	0.13	0.02	0.07	0.00	1.6	19	----	----
06:00	1557	13.5	160	1.04	4.89	5.93	73	2.65	122	6.78	0.85	0.14	0.48	0.01	0.3	4	----	----
07:00	1544	13	200	1.04	1.28	2.32	29	2.93	51	4.15	0.82	0.14	0.46	0.01	0	0	----	11

TABLE 9

ACTUAL AIRFLOWS
(cont'd)

DATE 19/04/89

TIME	FEED SCALE	FEED RATE	BURNER	FEED AIR	1ST STAGE AIR	TOTAL AIR	STOICH	2ND STAGE	STOICH	N2	SO2	O2 AS2O3	O2 Fe2O3	O2 Sb2O3	O2 LEFT	O2 OFF	OFF GAS 1ST	OFF GAS 2ND
	Kg	Kg/h	SCFH	(SCFM)	(SCFM)	(SCFM)	(%)	(SCFM)	(%)	(SCFM)	(SCFM)	(SCFM)	(SCFM)	(SCFM)	(SCFM)	(%)	% O2	% O2
08:00	1542	2	0	1.04	4.89	5.93	73	2.93	134	7.00	0.13	0.02	0.07	0.00	1.6	19	—	7.6
09:00	1520	22	0	1.04	4.89	5.93	73	2.93	134	7.00	1.39	0.23	0.78	0.01	0	0	—	4.8
10:00	1493.5	26.5	0	0.00	4.89	4.89	60	2.93	91	6.18	1.67	0.28	0.94	0.01	0	0	—	6
11:00	1480	13.5	0	1.04	4.89	5.93	73	2.93	134	7.00	0.96	0.16	0.55	0.01	0.2	2	—	—
12:00	1491.5	11.5	0	0.00	0	0.00	0	0	0	0	0	0	0	0	0	0	—	—
13:00	1491.5	0	0	0.00	0	0.00	0	0	0	0	0	0	0	0	0	0	—	—
14:00	1490.5	1	0	1.04	4.89	5.93	73	2.93	134	7.00	0.06	0.01	0.04	0.00	1.8	20	—	18
15:00	1488	1.5	0	1.04	0	1.04	13	1.32	19	1.86	0.09	0.02	0.06	0.00	0.3	14	—	—
16:00	1477.5	0	0	1.24	0	1.24	15	1.32	19	2.02	0	0	0	0	0.5	21	—	—
17:00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18:00	1453.5	0	0	1.24	0	1.24	15	1.32	19	2.02	0	0	0	0	0.5	21	—	—
19:00	1452.5	1	80	0.48	0	0.48	6	1.46	19	1.53	0.06	0.01	0.04	0.00	0.3	16	—	—

DATE 20/04/89

TIME	FEED SCALE	FEED RATE	BURNER	FEED AIR	1ST STAGE AIR	TOTAL AIR	STOICH	2ND STAGE	STOICH	N2	SO2	O2 AS2O3	O2 Fe2O3	O2 Sb2O3	O2 LEFT	O2 OFF	OFF GAS 1ST	OFF GAS 2ND
	Kg	Kg/h	SCFH	(SCFM)	(SCFM)	(SCFM)	(%)	(SCFM)	(%)	(SCFM)	(SCFM)	(SCFM)	(SCFM)	(SCFM)	(SCFM)	(%)	% O2	% O2
08:00																		
09:00																		
10:00	1440.5	0	200	0.48	0	0.48	6	0	0	0.38	0	0	0	0	0.1	21	—	—
11:00	1440.5	0	200	0.48	0	0.48	6	0	0	0.38	0	0	0	0	0.1	21	—	—
12:00	1440.5	0	200	0.48	0	0.48	6	0	0	0.38	0	0	0	0	0.1	21	—	—
13:00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14:00	1430	0	0	—	0	—	0	0	0	0	0	0	0	0	0	0	—	—
15:00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16:00	1412	0	200	0.35	0	0.35	4	1.32	17	1.32	0	0	0	0	0.4	21	—	—
17:00	1412	0	200	0.35	0	0.35	4	0	0	0.26	0	0	0	0	0.1	21	—	—
18:00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19:00	1412	0	200	1.24	0	1.24	15	2.65	39	3.07	0	0	0	0	0.8	21	—	—
20:00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21:00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22:00	1402	—	0	1.04	4.89	5.93	—	2.65	122	6.78	0	0	0	0	0	0	—	—
23:00	1386	16	0	1.04	4.89	5.93	73	2.65	122	6.78	1.01	0.17	0.57	0.01	0.0	1	—	—
24:00	1381	5	0	1.04	4.89	5.93	73	2.93	134	7.00	0.32	0.05	0.18	0.00	1.3	15	—	—
01:00	1365	16	160	1.04	1.28	2.32	29	2.93	51	4.15	1.01	0.17	0.57	0.01	0	0	—	—
02:00	1356	9	0	1.04	4.89	5.93	73	2.93	134	7.00	0.57	0.10	0.32	0.00	0.9	10	—	—
03:00	1338	18	0	1.04	4.89	5.93	73	2.93	134	7.00	1.13	0.19	0.64	0.01	0	0	—	—
04:00	1332	6	0	1.04	2.55	3.59	44	2.65	59	4.93	0.38	0.06	0.21	0.00	0.7	11	—	—
COUN	—	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	8	30
AVER	—	15.4	0	1.05	4.04	5.09	62.74	2.86	94	6.27	0.97	0.16	0.55	0.01	0.19	2.3	3.7	5.1
ST. DE	—	4.67	0	0.18	0.89	0.84	10.38	0.23	29	0.73	0.29	0.05	0.17	0.00	0.42	5.0	4.3	3.6
MAXIM	—	26.5	0	1.24	4.89	5.93	73.16	3.63	134	7.00	1.67	0.28	0.94	0.01	1.58	18.	15	18
MINIM	—	2	0	0	2.55	3.59	44.29	2.4	59	4.93	0.13	0.02	0.07	0.00	0.00	0	1.2	1.4

4.3 Final Commissioning Run (May 2-3, 1989)

A short 24 hour run was planned under steady state conditions after having feeding problems in the last run due to excessive abrasion of the feed auger. The auger was replaced and the plant was operated again for a period of 27 hours from May 2-3, 1989. The average feed rate during this run was 13.9 kg/hr which calculates to a required feedrate at 80% of stoichiometric to 5.85 SCFM air in the first stage and 1.610 SCFM air at 110% of stoichiometric in the second stage. Actual airflows averaged 78% of stoichiometric and 169% in the first and second stages. The higher airflow in the second stage did not appear to affect the calcine quality (in terms of colour). As in all previous runs the calcine colour from the first stage underflow was consistently black.

The average temperatures during the final commissioning period were 529°C in the first stage and 494°C in the second stage. First and second stage bed temperatures versus time elapsed are illustrated in Figure 7. Variance in bed temperature was the least of all previous runs at $\pm$ 40% in the first stage and $\pm$ 31°C in the second stage.

Air requirement calculations, log sheets for the run and calculated actual airflows are given in Tables 10, 11 and 12.

Chemical analyses of first and second stage roaster calcines for As and S showed that the first stage roaster was effective for removing arsenic. Arsenic in the original sulphide concentrate averaged 8.8% and was reduced to an average of 0.9% in the first stage calcine, a reduction of 92%. Arsenic in the final calcine averaged more than 1.2% indicating a concentrating effect due to the weight loss in further roasting in the second stage.

Both As and S was reduced to lower levels than Giant Yellowknife obtains (0.9% and 2.8%, respectively).

FIGURE 7
1ST & 2ND STAGE TEMPERATURE PROFILE
Average Temp. vs Time
Date: 02/5/89 18:00

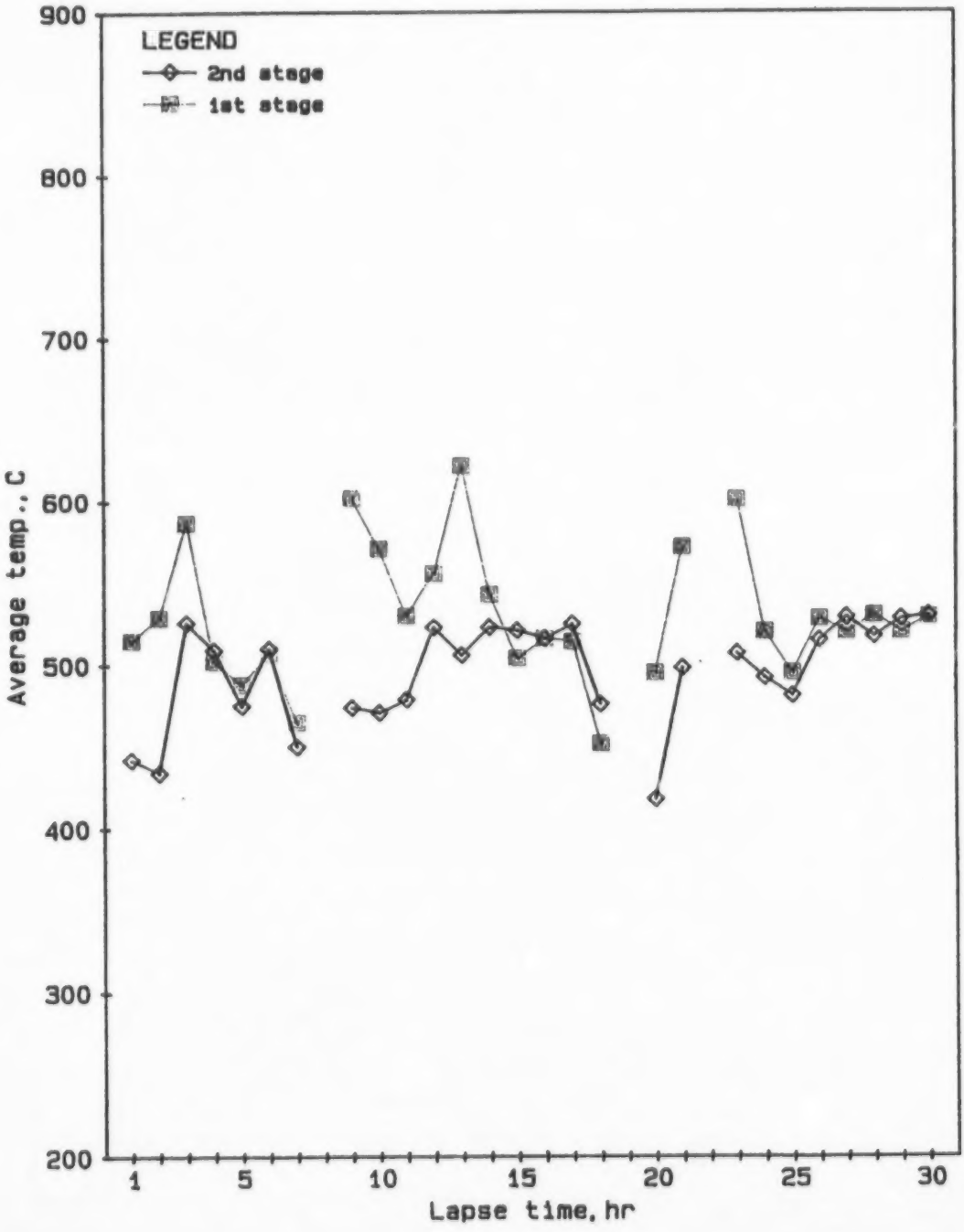


TABLE 10

AIRFLOW REQUIREMENTS

FEED RATE :	13.9	kg/hr			
% Pressure	100.0				
FEED ASSAY :					
Fe(%)	18.9				
As	8.8				
Sb	0.6				
S	15.5				
Au(oz)	1.839				
% S in Asp	4.7				
% S in Py	10.8				
% Pyrite	20.2				
% Asp	20.5				
Rate of Asp	2.8	kg/hr			
Rate of Py	2.8	kg/hr	FLOWRATE:	1kgmol=838.2 ft3	
O2 req'd(Asp)	0.05	mol/h	182.2	SCFH Air	
O2 req'd(Py)	0.06	mol/h	256.8	SCFH Air	
		TOTAL =	439.0	SCFH Air	
		=	7.3	SCFM Air	
Air requirements:					
1st stage	351.2	SCFH =	5.9	SCFM Air	
2nd stage	96.6	SCFH =	1.6	SCFM Air	
Elemental distribution:			Fe	S	As
Pyrite		%	9.4	10.8	–
Asp		%	7.2	4.7	8.8

DATE 2/5/89

TABLE 11 TWO STAGE GOLD ROAST OPERATING LOG

TIME	FEED SCALE Kg	FEED RATE Kg/h	H2O RATE L/m	TEMPERATURES 1ST STAGE PLEN	PLATE	B1	B2	B3	AVG	FB	EXIT	OFLO	2ND STAGE PLEN	PLATE	B1	B2	B3	AVG	FB1	FB2	EXIT	HGH HGH	HGO	IN	COND OUT	CBH	CBO	PRESSURES 1ST °H2O	2ND °H2O	HSOF °H2O	HSOUT °H2O	CBH °H2O	CBOF °H2O	CBOUT °H2O	BLOWER °H2O	AIR FLOWS FEED %	BURN	1ST	2ND	COND °H2O	OFF GAS 1ST %	2ND %
																												DAY SHIFT																
08:00																																												
09:00																																												
10:00																																												
11:00																																												
12:00																																												
13:00																																												
14:00																																												
15:00																																												
16:00																																												
17:00																																												
18:40	1419.5	----	----	672	574	515	514	514	514	436	384	70	----	390	442	442	441	441	463	376	375	373	402	401	169	144	137	-5.2	-9.9	1.3	-5.6	-20.7	0.8	-21.8	-22.6	80	200	35	20	15	----	----
19:00	1412.5	7	----	424	542	529	528	528	528	477	399	258	----	384	435	432	433	433	439	373	378	376	403	403	167	143	135	-5	-9.9	1.3	-5.9	-22	0.9	-23.4	-24.3	80	200	35	12	15	----	----
																												NIGHT SHIFT															
20:00	1393.5	19	25/on	142	423	594	572	592	586	483	437	141	396	----	526	525	525	525	----	412	391	385	405	408	159	136	129	-0.9	-5.2	0	-6.4	-23.1	1.6	-24.5	-26	0	0	34	22	15	----	----
21:00	1380.5	13	off/off	90	360	502	502	501	501	352	356	231	410	----	509	508	508	508	----	383	384	383	407	409	153	139	130	-0.6	-7.3	-0.8	-11.6	-37.2	1.6	-39	-42.6	0	0	36	22	15	----	----
22:00	1368	12	off/off	97	334	555	554	354	487	410	383	278	417	----	475	474	473	474	----	373	379	379	404	406	148	132	124	-1.3	-9	-0.8	-12.9	-39.3	1.6	-40.7	-45	0	0	38	22	15	----	----
23:00	1336.5	12.5	18/off	20	133	508	507	504	506	358	388	328	421	----	510	510	509	509	----	381	381	381	407	408	161	137	128	-0.6	-5.5	-3.1	-19.6	-58.5	1.6	-59.1	-60.1	0	0	40	22	15	----	----
24:00	----	----	----	750	550	485	484	483	484	361	370	218	426	----	450	449	448	449	----	367	373	375	402	405	184	143	125	-1.1	-10.3	0.8	-6.3	-29.2	1.2	-29.2	-30.9	0	210	0	22	15	----	----
01:00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
02:00	1346.5	16.5	18/off	131	391	602	601	600	601	455	401	284	428	----	475	470	476	473	----	387	382	379	404	406	149	129	120	-0.6	-8.6	-0.6	-12.2	-37.8	1.6	-39	-41.9	0	0	36	22	15	----	----
03:00	1324	12.5	20/off	106	371	572	570	569	570	362	593	323	427	----	471	471	470	470	----	379	383	381	408	411	147	136	125	0.1	-6	0.1	-7.2	-26.7	1.1	-27.7	-29.6	0	0	36	22	15	----	----
04:00	1309	15	20/off	105	347	530	529	529	529	325	380	292	421	----	479	478	478	478	----	381	380	379	405	413	137	131	122	0.7	-4	-0.8	-8.4	-26.5	1.6	-28	-28.9	0	0	30	22	15	----	----
05:00	1301	8	off/off	81	328	567	555	555	555	314	368	183	420	----	522	522	522	522	----	395	382	379	403	406	143	128	120	-0.6	-10	-1.2	-15.6	-47.3	1.6	-48.8	-53.2	0	0	30	22	15	----	----
06:00	1442.5	----	20/off	106	349	622	621	620	621	337	373	190	422	----	506	506	506	506	----	398	385	382	403	404	151	127	118	0	-6.8	-1.8	-15.5	-49.1	1.6	-50.8	-56.2	0	0	30	22	15	----	----
07:00	1428	14	20/off	129	344	543	542	541	542	321	381	239	422	----	521	523	523	522	----	399	387	385	403	406	144	131	121	0.7	-6.9	-0.4	-9.5	-30.6	1.6	-32.1	-33.7	0	0	30	22	15	----	----

DATE 03/05/89

TIME	FEED SCALE Kg	FEED RATE Kg/h	H2O RATE L/m	TEMPERATURES 1ST STAGE PLEN	PLATE	B1	B2	B3	AVG	FB	EXIT	OFLO	2ND STAGE PLEN	PLATE	B1	B2	B3	AVG	FB1	FB2	EXIT	HGH HGH	HGO	IN	COND OUT	CBH	CBO	PRESSURES 1ST °H2O	2ND °H2O	HSOF °H2O	HSOUT °H2O	CBH °H2O	CBOF °H2O	CBOUT °H2O	BLOWER °H2O	AIR FLOWS FEED %	BURN	1ST	2ND	COND °H2O	OFF GAS 1ST %	2ND %
																												DAY SHIFT															
08:00	1410	18		99	336	508	507	494	503	328	378	285	----	421	521	520	520	520	498	395	386	384	399	403	152	136	128	2.3	22.9	-10	-14.2	-47.8	1.6	-43.6	-47.9	80	----	30	22	15	----	----
09:00	1396	14		96	319	519	518	510	515	310	367	144	----	421	515	515	515	515	496	392	387	386	397	398	168	148	136	-1.7	-22.1	1.9	-15.8	-52.2	1.4	-54	-58	80	----	36	22	15	----	----
10:00	1384	12		88	319	514	513	513	513	295	357	94	----	421	525	525	524	524	497	392	384	382	391	394	162	147	136	-1.1	-20.8	1.8	-14.7	-50.8	1.6	-53	-57.6	80	----	36	22	15	----	----
11:00	1382	2		122	309	481	475	399	451	302	349	75	----	409	512	506	406	475	471	371	374	384	385	386	149	136	131	-2.8	-22.1	-2.8	-22.1	1.9	-18.2	-51.5	----	80	----	36	22	15	----	18
12:00	1374	8		----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
13:00	1483	----		596	550	494	494	494	494	405	379	104	----	399	418	417	416	417	470	372	376	375	378	380	161	142	132	-0.9	-22.1	1.9	-14.6	-49.1	1.5	-51.1	-55.2	80	----	30	22	15	----	----
14:00	1452	11		109	431	573	572	568	571	467	412	163	----	398	499	497	496	497	470	388	385	379	376	379	185	147	134	-1.4	-22.1	1.9	-15	-50.8	1	-51.4	-57	80	----	36	22	15	----	----
15:00	----	----		----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
16:00	1432.5	----		118	380	605	603	593	600	389	384	172	----	372	508	506	506	506	446	387	383	381	383	386	140	130	131	0	-15.6	1.4	-10.2	-34.1	0.8	-34.7	-37	80	----	36	22	15	----	----
17:00	1416.5	16		89	347	520	519	519	519	327	371	157	----	394	492	492	491	491	472	386	382	381	379	382	136	141	128	-0.6	-17.1	1.6	-10.3	-33.3	1	-35.6	-38.2	80	----	36	22	15	----	----
18:00	1439	----		156	331	509	487	487	494	305	355	86	----	402	480	480	480	480	479	372	378	376	375	379	128	135	124	-0.7	-16.5	1.8	-12	-35.3	0.9	-35.9	-37.6	80	----	36	22	15	----	----
19:00	1426	15		95	323	531	530	521	527	327	368	200	----	397	514	514	514	514	474	386	383	381	380	384	133	142	130	-0.2	-15	1.5	-10.5	-37.2	1.6	-39.1	-40.7	80	----	36	22	15	----	----
																												NIGHT SHIFT															
20:00	1410	16		81	316	520	519	519	519	323	362	153	406	----	523	531	531	528	----	381	380	380	383	386	153	141	132	-1.3	-22.1	1.8	-17.7	-48.6	1.6	-48.3	-51.9	80	0	36	22	15	----	----
21:00	1394.5	15.5		106	320	531	529	527	529	317	364	273	412	----	518	516	518	516	----	385	382	380	385	387	162	142	131	0.7	-6.3	-2.2	-17.8	-45.7	1.6	-46.5	-52.9	80	0	36	22	15	----	----
22:00	1381.5	13		86	326	521	520	518	519	333	368	223	415	----	526	527	526	527	----	386	382	380	386	387	158	142	131	0.2	-14.8	0	-16.5	-41.8	1.6	-43.4	-47.1	80	0	36	22	15	----	----
23:00	1366	24.5		106	319	530	529	527	528	322	363	306	418	----	530	529	526	529	----	387	381	380	390	394	154	136	127	0.8	-7.3	-2.1	-16.6	-41.6	1.6	-43.5	-48.2	80	0	36	22	15	----	----
24:00																																											
01:00																																											
02:00																																											
03:00																																											
04:00																																											
05:00																																											
06:00																																											
07:00																																											
COUN	---	22	---	27	27	27	27	27	27	27	27	27	15	12	27	27	27	27	12	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	26	27	27	27	27	27	----	----
AVG	---	13.3	---	180	370.8	535	532	520	529	360	384	201.	417	460.6	496	495	491	494	472	384	381	380	394	398	151	136	128	-0.7	-11.2	-0.2	-12.8	-37.4	0.866	-40.6	-43.819	47.	22.59	34.	21.	15	----	----
ST.DE	---	4.52	---	187	95.12	37.	37.	55.	40.	86.	44.	77.0	8.3	14.69	30.	31.	35.	31.	17.	10.	4.0	3.1	11.	11.	10.	8.9	8.2	1.85	9.109	2.45	4.259	12.70	3.711	10.27	11.9971	39.	63.62	7.9	1.9	0	----	----
MAX	---	24.5	---	750	550	622	621	620	621	483	593	328	428	421	530	531	531	529	498	412	391	386	408	413	169	148	137	2.3	22.9	1.9	-6.6	1.9	1.6	-21.8	-22.6	80	210	40	22	15	----	----
MIN	---	2	---	20	133	485	484	354	451	295	349	70	396	372	418	417	406	417	439	367	373	373	375	379	128	127	118	-8.2	-22.1	-10	-22.1	-58.5	-18.2	-58.1	-69.1	0	0	0	12	15	----	----

TABLE 12

ACTUAL AIRFLOWS

DATE 2/5/89

TIME	FEED SCALE	FEED RATE	BURNER	FEED AIR	1ST STAGE AIR	TOTAL AIR	STOICH	2ND STAGE	STOICH	N2	SO2	O2 AS2O3	O2 Fe2O3	O2 Sb2O3	O2 LEFT	O2 OFF	OFF GAS 1ST	OFF GAS 2ND
	Kg	Kg/h	SCFH	(SCFM)	(SCFM)	(SCFM)	(%)	(SCFM)	(%)	(SCFM)	(SCFM)	(SCFM)	(SCFM)	(SCFM)	(SCFM)	(%)	% O2	% O2
18:40	1419.5	----	200	1.04	4.89	5.93	81	2.65	191	6.78	----	----	----	----	----	----	----	----
19:00	1412.5	7	200	1.04	4.89	5.93	81	1.6	115	5.95	0.44	0.07	0.25	0.00	0.8	11	----	----
20:00	1393.5	19	0	0	4.72	4.72	65	2.93	113	6.04	1.20	0.20	0.67	0.01	0	0	----	----
21:00	1380.5	13	0	0	5.5	5.5	75	2.93	161	6.66	0.82	0.14	0.46	0.01	0.3	4	----	----
22:00	1368	12	0	0	5.5	5.5	75	2.93	161	6.66	0.76	0.13	0.42	0.01	0.5	6	----	----
23:00	1336.5	12.5	0	0	5.9	5.9	81	2.93	207	6.98	0.79	0.13	0.44	0.01	0.5	6	----	----
24:00	----	----	210	0	0	0	0	2.93	40	2.31	----	----	----	----	----	----	----	----
01:00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
02:00	1366.5	16.5	0	0	5.5	5.5	75	2.93	161	6.66	1.04	0.18	0.58	0.01	0	0	----	----
03:00	1324	12.5	0	0	4.89	4.89	67	2.93	121	6.18	0.79	0.13	0.44	0.01	0.3	4	----	----
04:00	1309	15	0	0	4.05	4.05	55	2.93	90	5.51	0.95	0.16	0.53	0.01	0	0	----	----
05:00	1301	8	0	0	4.05	4.05	55	2.93	90	5.51	0.50	0.08	0.28	0.00	0.6	9	----	----
06:00	1442.5	----	0	0	4.05	4.05	55	2.93	90	5.51	----	----	----	----	----	----	----	----
07:00	1428	14	0	0	4.05	4.05	55	2.93	90	5.51	0.88	0.15	0.50	0.01	0	0	----	----

DATE: 03/05/89

TIME	FEED SCALE	FEED RATE	BURNER	FEED AIR	1ST STAGE AIR	TOTAL AIR	STOICH	2ND STAGE	STOICH	N2	SO2	O2 AS2O3	O2 Fe2O3	O2 Sb2O3	O2 LEFT	O2 OFF	OFF GAS 1ST	OFF GAS 2ND
	Kg	Kg/h	SCFH	(SCFM)	(SCFM)	(SCFM)	(%)	(SCFM)	(%)	(SCFM)	(SCFM)	(SCFM)	(SCFM)	(SCFM)	(SCFM)	(%)	% O2	% O2
08:00	1410	16	----	1.04	4.05	5.09	70	2.93	132	6.34	1.13	0.19	0.64	0.01	0	0	----	----
09:00	1396	14	----	1.04	5.5	6.54	89	2.93	378	7.48	0.88	0.15	0.50	0.01	0.5	5	----	----
10:00	1384	12	----	1.04	5.5	6.54	89	2.93	378	7.48	0.76	0.13	0.42	0.01	0.7	8	----	----
11:00	1382	2	----	1.04	5.5	6.54	89	2.93	378	7.48	0.13	0.02	0.07	0.00	1.8	19	----	18
12:00	1374	8	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
13:00	1463	----	----	1.04	2.55	3.59	49	2.93	79	5.15	0	0	0	0	0	0	----	----
14:00	1452	11	----	1.04	5.5	6.54	89	2.93	378	7.48	0.69	0.12	0.39	0.01	0.8	9	----	----
15:00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
16:00	1432.5	----	----	1.04	5.5	6.54	89	2.93	378	7.48	0	0	0	0	0	0	----	----
17:00	1416.5	16	----	1.04	5.5	6.54	89	2.93	378	7.48	1.01	0.17	0.57	0.01	0.2	3	----	----
18:00	1439	----	----	1.04	5.5	6.54	89	2.93	378	7.48	0	0	0	0	0	0	----	----
19:00	1426	15	----	1.04	5.5	6.54	89	2.93	378	7.48	0.95	0.16	0.53	0.01	0.3	4	----	----
20:00	1410	16	0	1.04	5.5	6.54	89	2.93	378	7.48	1.01	0.17	0.57	0.01	0.2	3	----	----
21:00	1394.5	15.5	0	1.04	5.5	6.54	89	2.93	378	7.48	0.98	0.16	0.55	0.01	0.3	3	----	----
22:00	1381.5	13	0	1.04	5.5	6.54	89	2.93	378	7.48	0.82	0.14	0.46	0.01	0.6	6	----	----
23:00	1368	24.5	0	1.04	5.5	6.54	89	2.93	378	7.48	1.54	0.26	0.87	0.01	0	0	----	----
COUN	----	20	----	20	20	20	20	20	20	20	20	20	20	20	20	20	----	----
AVER	----	13.9	----	0.67	5.16	5.73	78.35	2.93	185	6.84	0.88	0.15	0.49	0.01	0.38	4.4	----	----
ST. DE	----	4.31	----	0.52	0.60	0.93	12.73	0	0	0.74	0.27	0.05	0.15	0.00	0.40	4.4	----	----
MAXIM	----	24.5	----	1.04	5.90	6.54	89.39	2.93	377.5	7.48	1.54	0.26	0.87	0.01	1.77	19	----	----
MINIM	----	2	----	0	4.05	4.05	55.36	2.93	89.7	5.51	0.13	0.02	0.07	0.00	0	0	----	----

5.0 CYANIDE EXTRACTION EFFICIENCY TESTS

A total of 24 samples were selected from the three commissioning runs for testing for gold extractability by means of 24 hour bottle roll cyanide leach tests. The methodology used for the leaches was the same as that at Giant Yellowknife:

Four hundred millilitres of water were brought up to pH 11.5 with lime prior to the addition of 0.05% NaCN. The solution was transferred to a Winchester bottle with 200 grams of calcine added with sufficient lime to maintain the pH. The bottle was placed on rolls and after one hour removed, left to settle and a 25 ml sample of solution was taken for titration to determine the CN level. Additional CN was added to maintain a concentration of 0.05% and lime to give a pH of 11.5. The concentration levels were checked and adjusted after 6 hours. After 24 hours on the rolls the samples were filtered through a buchner funnel and the residue washed with water. Samples of head, residue and filtrate were sent for assay. Head and residue samples were analyzed for gold by fire assay and the filtrate was analyzed by the A-A. The results of the tests are summarized in Table 13 and detailed in Table 14. Selected samples from first stage bed underflow calcine and second stage overflow were analyzed by ICAP for As and S (Table 13 and 14). The term residue extraction in Tables 13 and 14 refers to gold extraction efficiencies calculated using gold fire assay data from head and residues after bottle roll tests. Solution extraction in these tables refers to calculations of gold extraction efficiency using fire assay data from head calcine and AA data from cyanide leach filtrates.

Gold extraction efficiencies calculated from head and residue assays after 24 hour bottle roll tests gave an average of 78% extraction for 21 tests. Giant Yellowknife Mines obtain 94% extraction efficiency by cyanidation. The maximum extraction of all tests was 91% on samples taken while airflows to the second stage roaster were doubled, resulting in a red calcine. This result must be confirmed in subsequent testwork. Material balances calculated from the soltuion analyses were anomolous and the solution analysis were not used in assessing the results.

TABLE 13

CYANIDE LEACH TEST AND ASSAY RESULTS

DATE	TIME	HEAD ASSAY (oz/ton)	RESIDUE ASSAY (oz/ton)	RESIDUE EXTRACT'N (%)	% As 1st stage	% S 1st stage	% As 2nd stage	% S 2nd stage
11/04/89	04:00	1.071	0.979	9.37				
	08:00	1.562	0.799	52.48				
	14:00	2.094	0.979	53.74				
	16:00	1.878	0.358	81.07				
	22:00	2.231	0.681	68.94				
12/04/89	02:00	2.138	0.436	78.69	0.80	2.86	1.53	2.04
	06:00	2.134	0.579	72.44				
13/04/89	01:00	1.990	0.180	91.19	0.69	5.14	0.66	1.71
17/04/89	21:00	2.000	0.360	82.15	0.79	6.06	0.99	1.49
18/04/89	07:00	2.030	0.462	77.19	0.64	11.52	0.60	2.00
	11:00	2.146	0.412	81.13	0.57	10.40	0.59	1.42
	14:00	2.457	0.324	87.14	0.62	9.91	0.68	2.31
	17:00	2.351	0.300	87.33	0.83	3.84	0.97	1.91
	21:00	1.874	0.657	65.12	1.32	8.00	1.45	1.98
19/04/89	03:00	2.257	0.421	81.47	1.17	7.04	2.00	2.94
	23:00	2.004	0.587	71.06	1.74	8.65	1.57	2.28
21/04/89	03:00	1.876	0.579	69.45				
02/05/89	23:00	2.046	0.412	79.64	1.13	3.54	1.61	1.67
03/05/89	03:00	1.846	0.559	69.77	0.65	1.62	1.55	1.96
	07:00	1.922	0.352	81.89	0.85	2.53	1.12	1.42
	11:00	1.798	0.394	78.23				
	15:00	1.498	0.402	73.54	0.65	3.66	1.20	1.84
	19:00	1.646	0.288	82.54				
	23:00	1.750	0.499	71.31	1.09	6.88	1.50	1.87
BAKED		1.654	0.348	79.08				
24 HRS		2.008	0.380	81.14				
48 HRS		2.008	0.346	82.95				
0.1% CN		2.008	0.368	81.96				
10.5 pH		2.008	0.362	82.20				
GROUND FINE		2.008	0.308	84.64				
CBH		0.823						
HBH		2.092						

TABLE 14

DETAILED CYANIDE LEACH AND ASSAY TEST RESULTS

DATE	TIME	HEAD WEIGHT (g)	HEAD ASSAY (oz/ton)	CRUSHED RESIDUE WEIGHT (g)	CRUSHED RESIDUE ASSAY (oz/ton)	UNCRUSHED RESIDUE ASSAY (oz/ton)	HEAD (g Au)	RESIDUE CRUSHE (g Au)	RESIDUE UNCRUSHE (g Au)	FILTRATE ASSAY (ppm)	FILTRATE CRUSHE (g Au)	FILTRATE UNCRUSHED (ppm)	FILTRATE UNCRUSHED (g Au)	EXTRACTION CRUSHED RESIDUE (%)	EXTRACTION CRUSHED SOL'N (%)	EXTRACTION UNCRUSHED RESIDUE (%)	EXTRACTION UNCRUSHED SOL'N (%)	CN- CONSUMPT'N (g)	% As 1st stage	% S 1st stage	% As 2nd stage	% S 2nd stage
11/04/89	04:00	200.00	1.071	196.30	0.979		0.0067	0.0061		< 1	---			9.37	---			0.372				
	08:00	200.00	1.562	185.81	0.799		0.0098	0.0046		8	0.0032			82.48	32.78			0.468				
	14:00	200.00	2.094	197.91	0.979		0.0131	0.0061		22	0.0088			53.74	67.24			0.352				
	18:00	200.00	1.878	198.56	0.356		0.0117	0.0022		28.70	0.0115			81.07	97.81			0.404				
	22:00	200.00	2.231	203.48	0.681		0.0139	0.0043		22.70	0.0091			68.94	66.12			0.506				
12/04/89	02:00	200.00	2.138	208.96	0.436		0.0134	0.0026		28.70	0.0115			78.89	88.91			0.552	0.88	2.66	1.53	2.84
	06:00	200.00	2.134	203.16	0.579		0.0133	0.0037		21.60	0.0086			72.44	64.48			0.564				
13/04/89	01:00	200.00	1.990	194.78	0.180		0.0124	0.0011		28.70	0.0115			91.19	92.30			0.184	0.69	5.14	0.66	1.71
17/04/89	21:00	200.00	2.000	196.36	0.360		0.0125	0.0022		29.90	0.0179			82.15	93.68			0.470	0.79	5.65	0.99	1.48
18/04/89	07:00	200.00	2.036	200.41	0.467		0.0127	0.0029		33.40	0.0134			77.19	109.30			0.432	0.84	11.52	0.80	2.80
	11:00	200.00	2.146	198.58	0.412	0.154	0.0134	0.0025	0.0013	26.30	0.0105			81.13	78.43	81.11		0.506	0.57	10.48	0.55	1.48
	14:00	200.00	2.437	193.11	0.384	0.159	0.0134	0.0025	0.0015	17.60	0.0070	44.00	0.0176	87.12	44.80	84.15	114.81	0.378	0.53	3.91	0.55	1.48
	17:00	200.00	2.351	192.60	0.380		0.0147	0.0015		26.80	0.0132	43.00	0.0179	87.93	168.46		117.98	0.400	0.53	3.94	0.57	1.51
	21:00	200.00	1.874	198.99	0.057	0.382	0.0117	0.0041	0.0116	21.00	0.0084	24.20	0.0106	66.12	71.72	88.03	98.62	0.304	1.39	8.89	1.43	1.98
19/04/89	03:00	200.00	2.257	198.73	0.481		0.0141	0.0026		18.60	0.0060	26.00	0.0112	81.47	42.63		79.46	0.332	1.17	7.84	2.00	2.84
	23:00	200.00	2.004	197.66	0.567	0.282	0.0125	0.0034	0.0017	27.80	0.0139			71.66	84.33	86.10		0.416	1.74	8.65	1.17	2.28
21/04/89	03:00	200.00	1.878	198.00	0.579	0.435	0.0117	0.0036	0.0027	27.00	0.0088	32.00	0.0128	68.46	78.06	77.16	108.17	0.472				
22/04/89	23:00	200.00	2.046	202.20	0.412		0.0128	0.0026		25.00	0.0156			75.84	121.99			0.432	1.13	3.54	1.81	1.87
23/04/89	03:00	200.00	1.848	199.67	0.660		0.0115	0.0030		24.00	0.0149			66.77	101.34			0.480	0.86	1.62	1.36	1.58
	07:00	200.00	1.822	197.78	0.362		0.0130	0.0022		44.00	0.0184			61.89	103.17			0.372	0.98	2.53	1.13	1.47
	11:00	200.00	1.790	198.86	0.384		0.0112	0.0024		26.00	0.0104			78.73	92.65			0.368				
	15:00	200.00	1.498	197.23	0.498		0.0094	0.0025		28.00	0.0104			73.04	111.08			0.388	0.85	2.66	1.20	1.84
	19:00	200.00	1.848	198.80	0.258		0.0105	0.0018		31.00	0.0124			62.84	120.63			0.420				
	23:00	200.00	1.750	201.30	0.498		0.0100	0.0031		34.00	0.0136			71.31	134.34			0.488	1.20	6.60	1.30	1.87
BAKED		200.00	1.854	198.63	0.648		0.0103	0.0027		31.00	0.0124			79.00	118.05							
24 HRS		200.00	2.000	199.20	0.300		0.0120	0.0024		31.00	0.0124			81.16	96.00							
48 HRS		200.00	2.000	197.93	0.348		0.0120	0.0021		27.00	0.0108			82.96	93.98							
0.1% CN		200.00	2.000	198.04	0.360		0.0120	0.0023		32.40	0.0129			81.98	105.98							
10.5 pH		200.00	2.000	197.49	0.362		0.0120	0.0022		36.00	0.0144			82.30	114.74							
GROUND FINE		200.00	2.000	200.30	0.306		0.0120	0.0019		29.60	0.0118			84.84	88.43							
CSH		200.00	0.823																			
HSH		200.00	2.097																			

No correlation was established between the test materials, pilot plant operation and gold extraction or % As in the calcine and gold dissolution. The variables influencing gold recovery can be divided into those affecting cyanidation itself (gold content, leaching) and the roasting parameters (calcine S & As, bed temperatures, plenum S & As, % stoichiometry, feed rate, etc.) Each of these were examined. The diagramatic presentations of this analysis are given in Appendix B, Figure 1 to 10.

An additional series of cyanide leach tests were carried out on a bulk sample which assayed 2 oz/ton to investigate whether the poor extractions could be improved. Variables such as extending the leach an additional 48 hours, doubling the concentration of cyanide from 0.05% to 0.1%, decreasing pH to 10.5 and extra fine grinding were all tested. The standard leach on the bulk sample yielded 81.14% extraction which increased to 82.95% after a 48 hour leach. Ultra fine grinding increased the extraction to 84.64%. A sample of calcine from 03/05/89 at 11:00 was baked at 525°C for 2 hours prior to leaching, with no significant change in Au extraction. The results are given in Tables 13 and 14.

Samples collected from the hot baghouse (HBH) and cold baghouse (CBH) assayed 2.092 and 0.823 oz/ton. Calcine losses to both HBH and CBH represent about 25% by weight. CBH product was consistently tainted by calcine contaminants as the woven ceramic filter bags in the HBH failed to collect all the non volatile elutriated calcine fines. These bags are very fragile and tend to fail if not installed carefully or blown back with excessive force. Between the second commissioning run and the final commissioning run the bags were replaced with new ones. The test, however, was not run long enough to allow the contamination built up in the off gas lines to clean itself out. As a result samples collected in the CBH continued to be tainted. Due to the high arsenic in both HBH and CBH calcines bottle roll tests were not possible.

6.0 CONCLUSIONS

In drawing conclusions about this project it must be remembered that the object was to commission a two-stage roaster for treatment of refractory gold ores and not to undertake a test program. Hence:

i The commissioning was successful because a large number of hours of continuous operation were obtained.

Mechanical and Preliminary Commissioning (March 20-31)
Total operating hours = 70

Commissioning (April 10 - May 5)
Total operating hours = 161

ii Operation of the pilot plant and control of the process was achieved. Mechanical breakdowns of process equipment did not adversly affect the overall operations.

iii The first stage reduction roasting effectively removed arsenic from the concentrate.

iv The second stage oxidation roast to remove sulphur to leave a hematitic iron calcine was also achieved.

v It is not known why lower gold extraction rates were obtained than are achieved by Giant Yellowknife. More work would be needed to establish if it was a function of roasting practice, the cyanidization process or both.

7.0 FUTURE ACTION

The following analysis will be important in formulating an action plan that will demonstrate the use and versatility of the RPC two stage fluidized bed roaster and that will allow its involvement in useful work for the Canadian mining industry.

1. This report will be sent to the RPC consulting pyrometallurgist, Dr. Igor Wilkomirsky and to Giant Yellowknife for review. Their experience will allow them to advise on details of the operation of the unit and the equipment itself. The opinion of CANMET roasting experts will also be important in evaluating the performance of this equipment.

2. A bulk calcine sample should be obtained from Giant Yellowknife for leach testing to verify that their extractions can be duplicated in our laboratory.

3. Samples of calcine should be examined using the electron microprobe to check whether any vitrification occluding the pores has taken place.

APPENDIX A

A REPORT ON THE DEVELOPMENT OF ROASTING TECHNOLOGY FOR GOLD-BEARING ARSENICAL SULPHIDE CONCENTRATE

WORK STATEMENT

RPC's present single stage fluidized bed roaster would be modified by adding a second stage roaster. The first stage reduction roast (to drive off arsenic) will operate at 500°C, and the oxidation roast at 530°C. The off gases will pass through a hot metal fabric baghouse, a condenser, and a cold baghouse.

The unit will be commissioned during two 5 day, 3 shift, trials. Gold-bearing arsenopyrite concentrate from Giant Yellowknife will be fed to the roaster as a slurry. Roasting conditions will be varied during the runs, with samples taken after steady-state conditions are reached. The data collected during the pilot plant operation and the cyanide leach tests will be compared with industrial operations.

APPENDIX B
VARIABLES EFFECTING GOLD EXTRACTION

FIGURE 1

GOLD EXTRACTION VS %As, %S IN 1ST STAGE
EXTRACTION BASED ON RESIDUE ANALYSIS

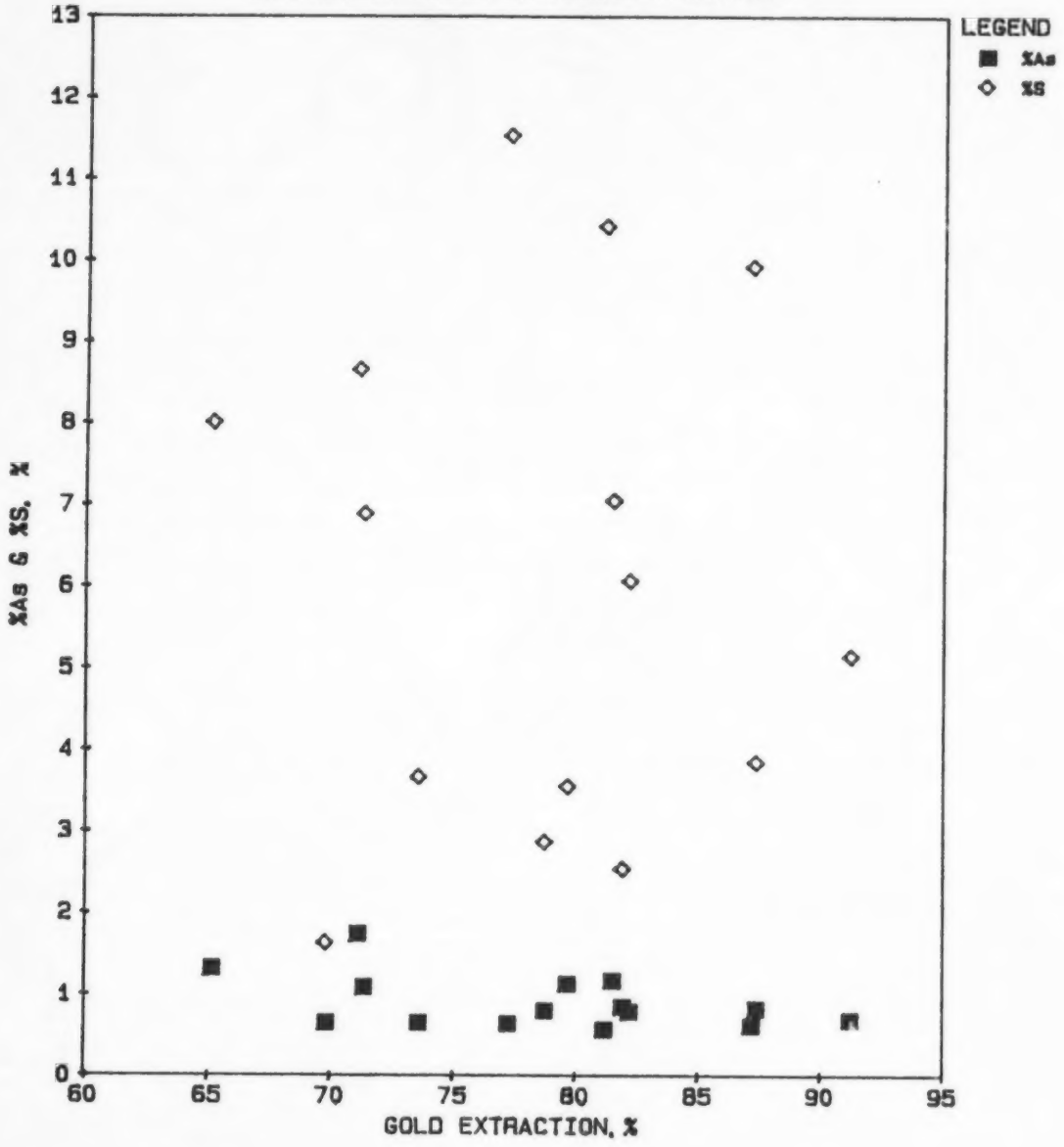


FIGURE 2

GOLD EXTRACTION VS %S IN THE CALCINE
EXTRACTION BASED ON RESIDUE ANALYSIS

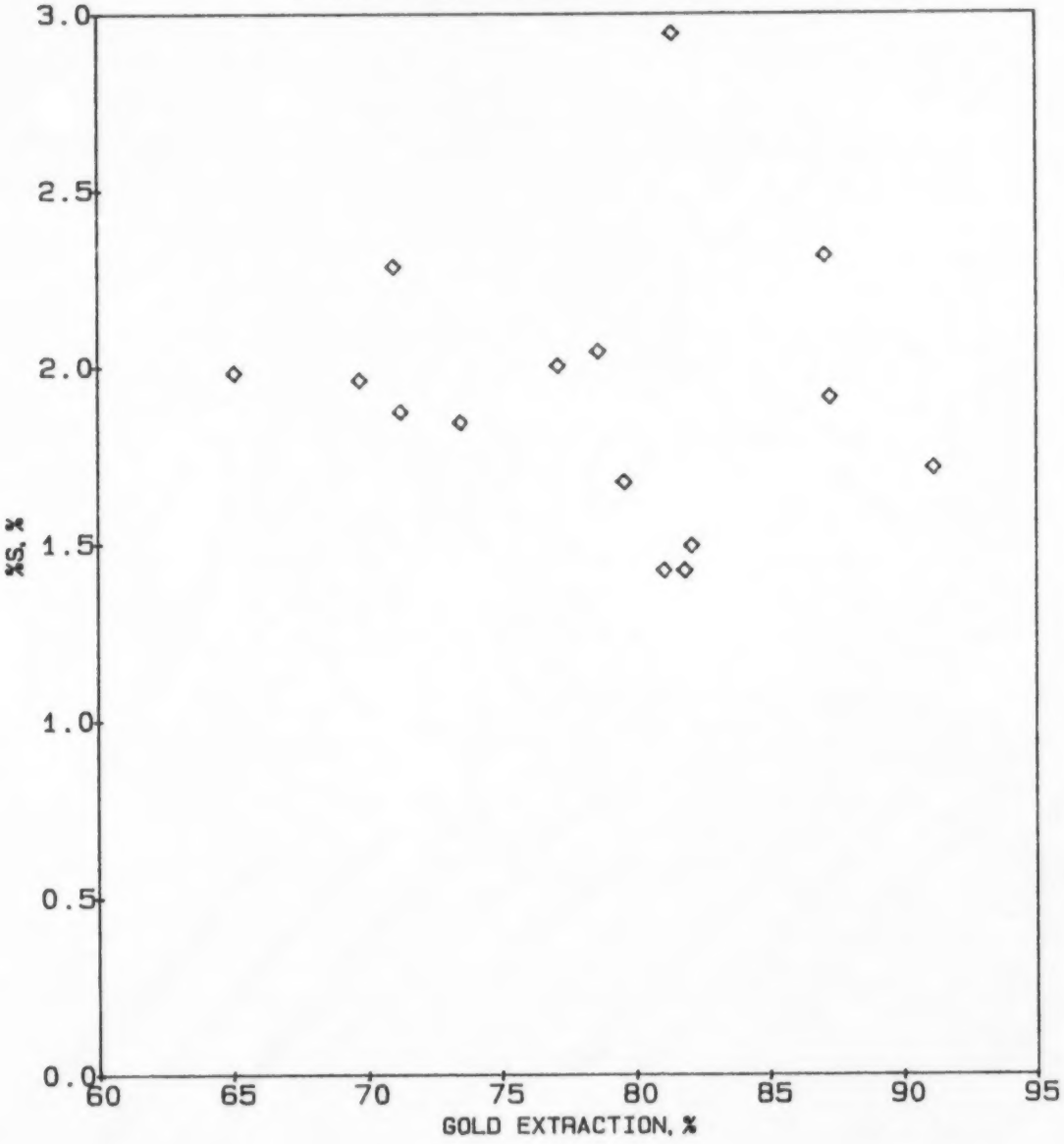


FIGURE 3

GOLD EXTRACTION VS %As IN THE CALCINE
EXTRACTION BASED ON RESIDUE ANALYSIS

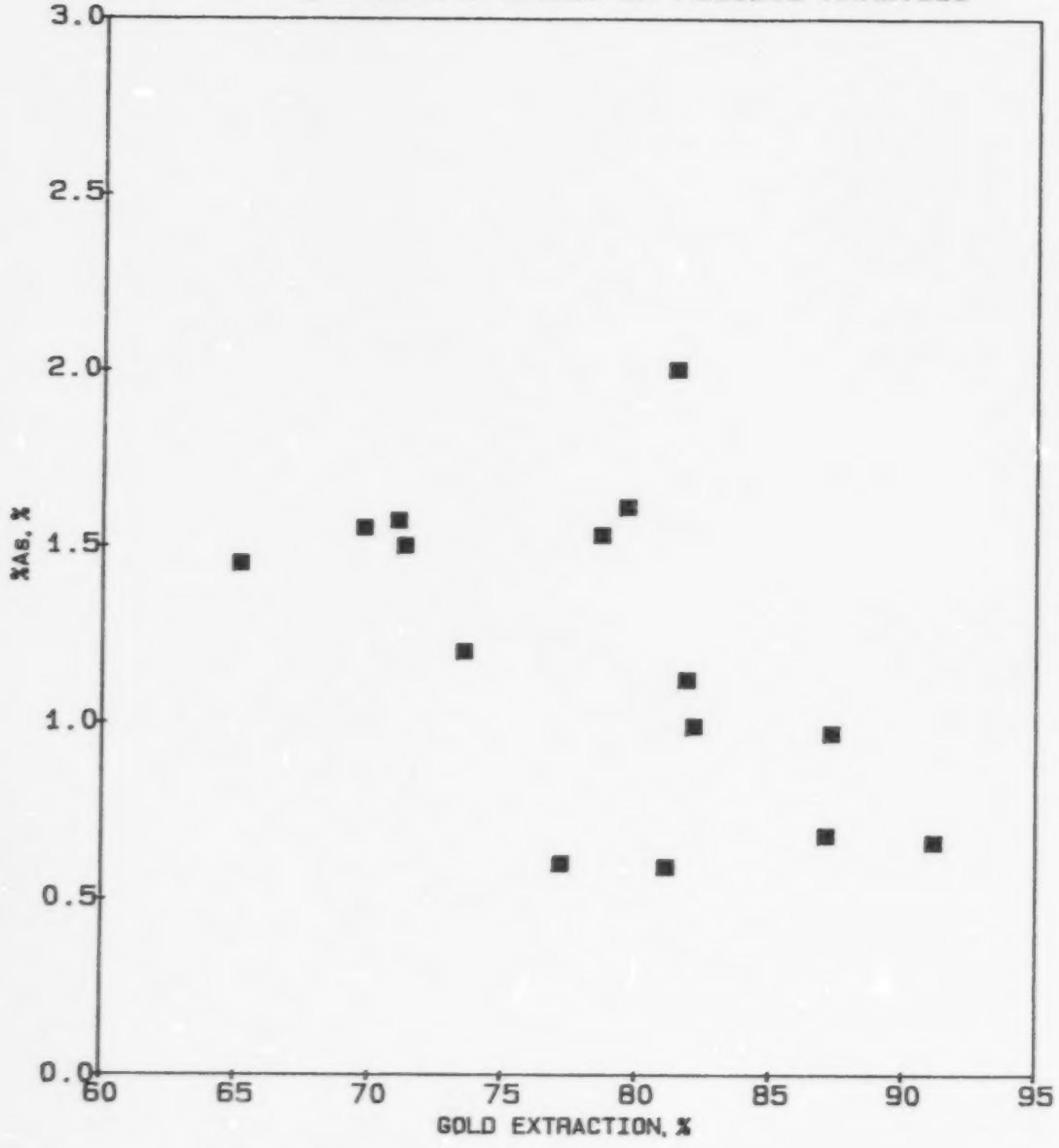


FIGURE 4A

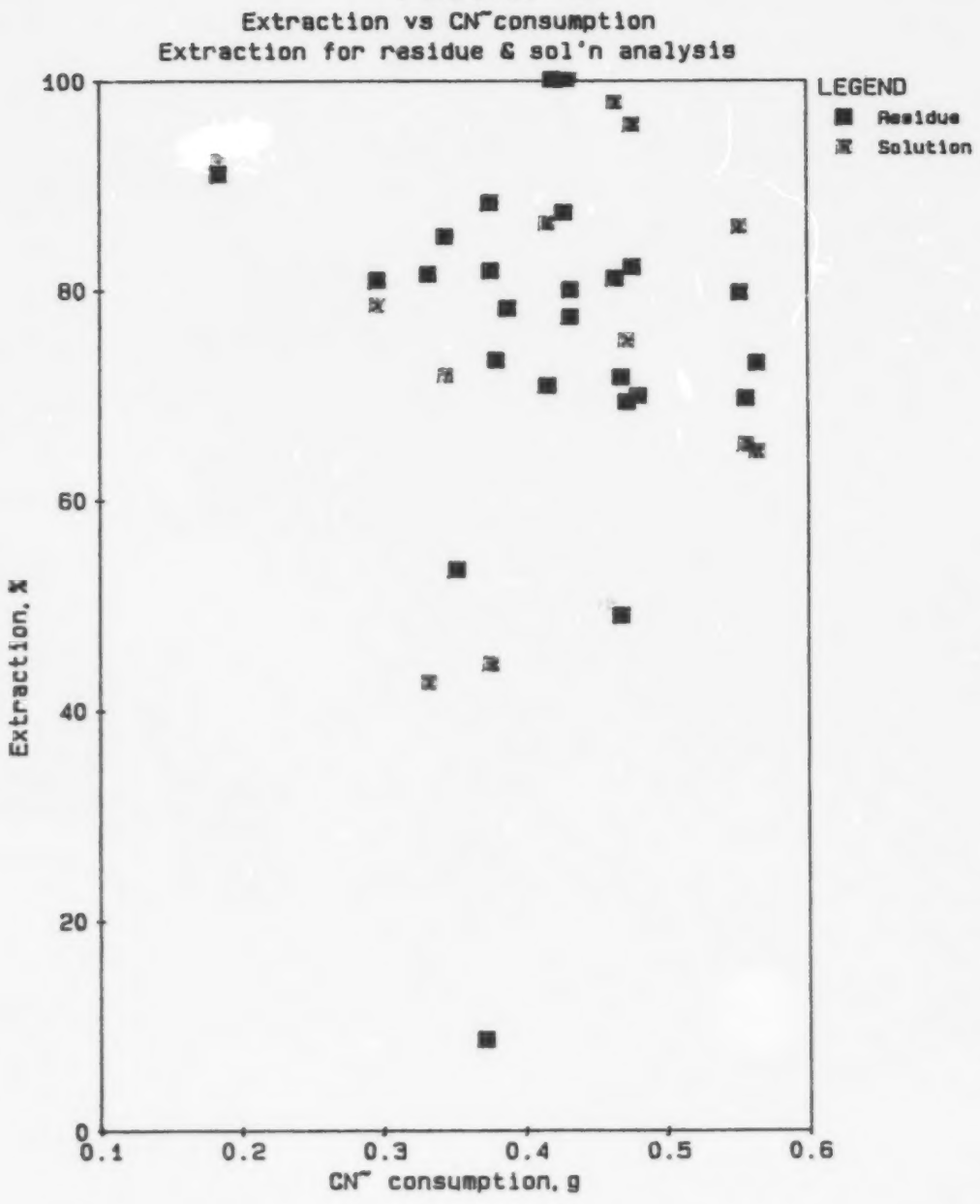

Extraction vs CN⁻consumption
Extraction for residue & sol'n analysis
LEGEND
Residue
Solution
Extraction, %
100
80
60
40
20
0
0.1
0.2
0.3
0.4
0.5
0.6
CN⁻ consumption, g

FIGURE 5

2ND STAGE ASSAY

2nd stage %S vs CN^- consumption

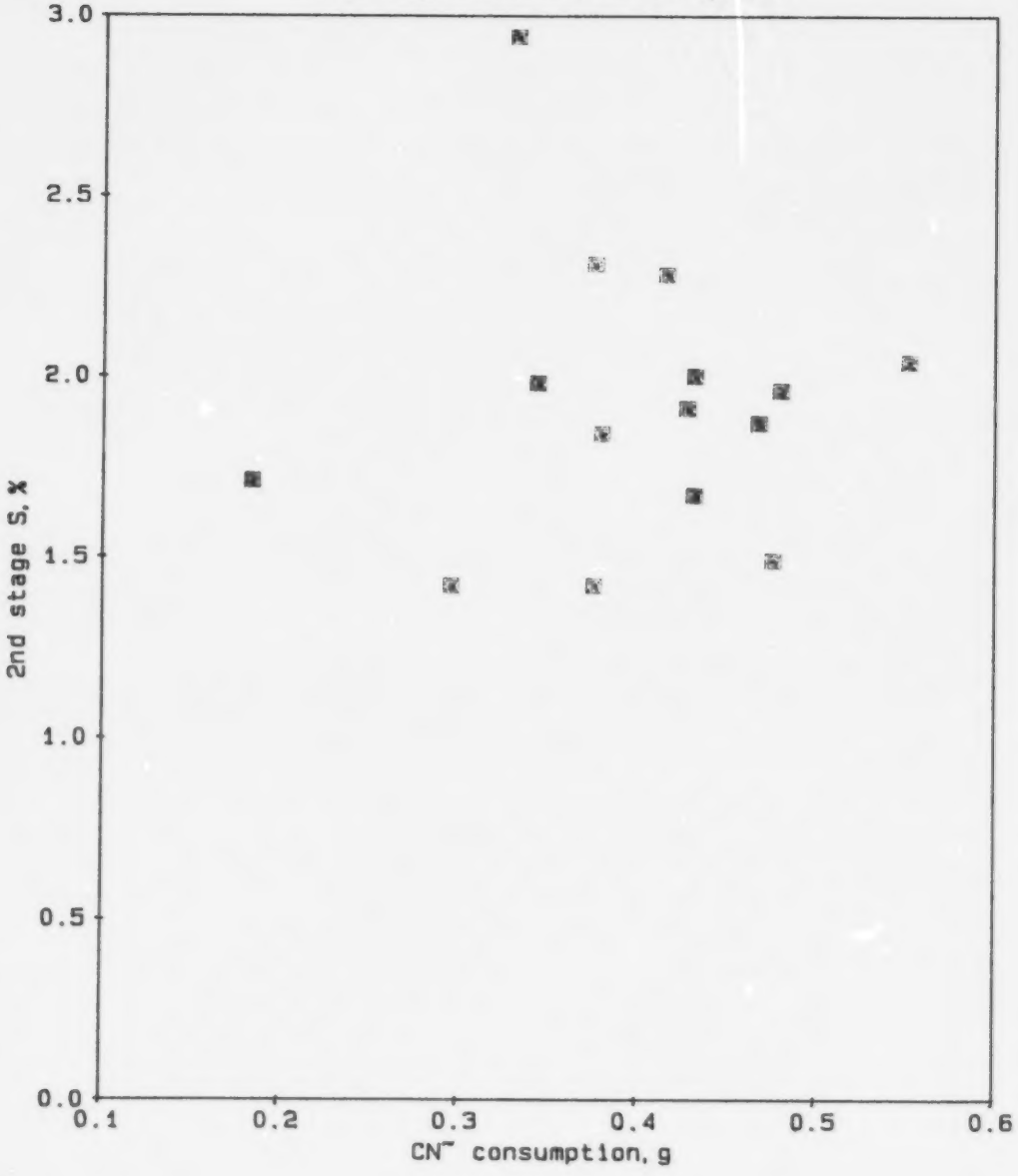


FIGURE 6

2ND STAGE ASSAY

2nd stage %As vs CN~ consumption

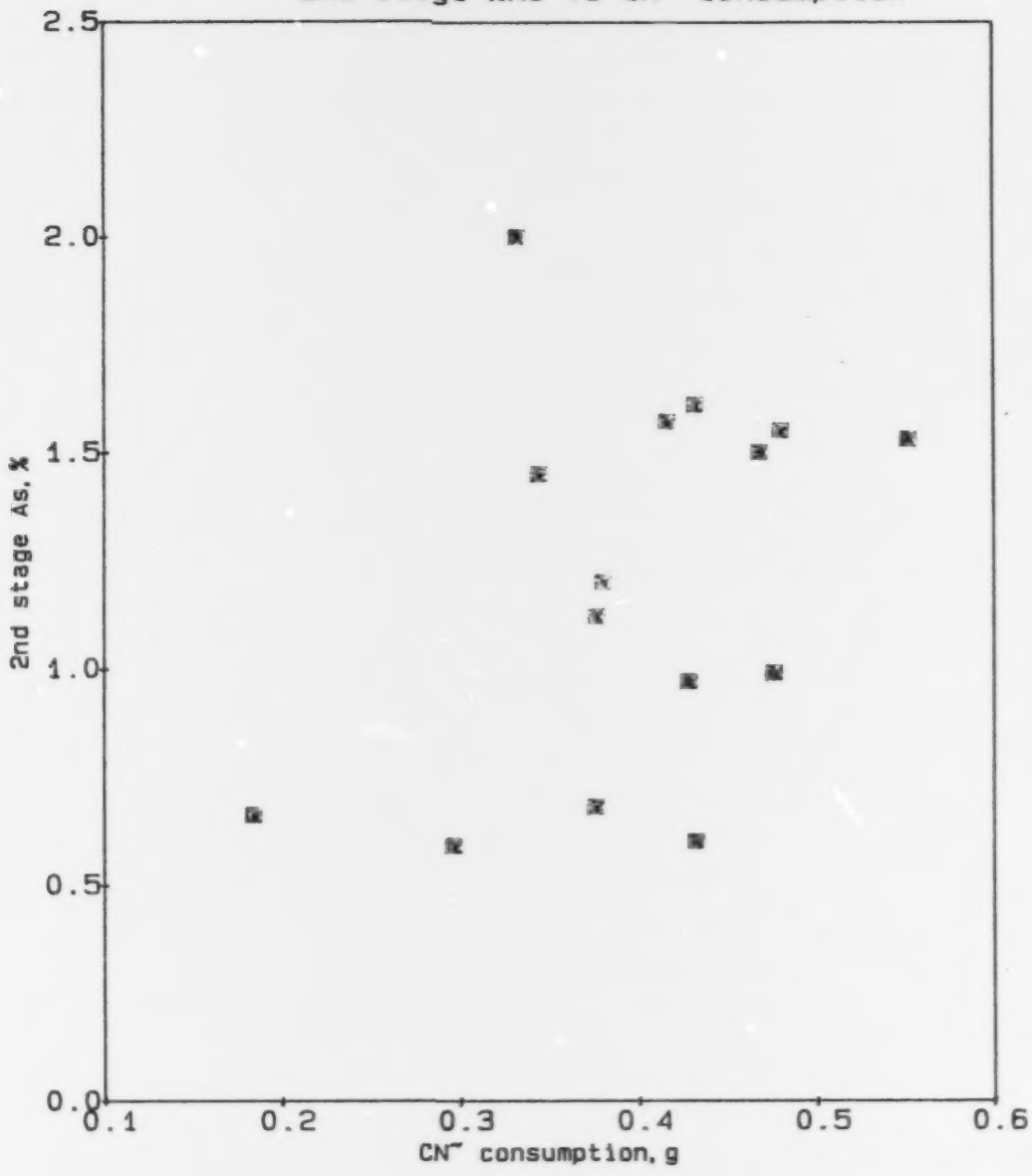


FIGURE 7

Temperatures vs Residue extraction
Extraction based on residue analysis

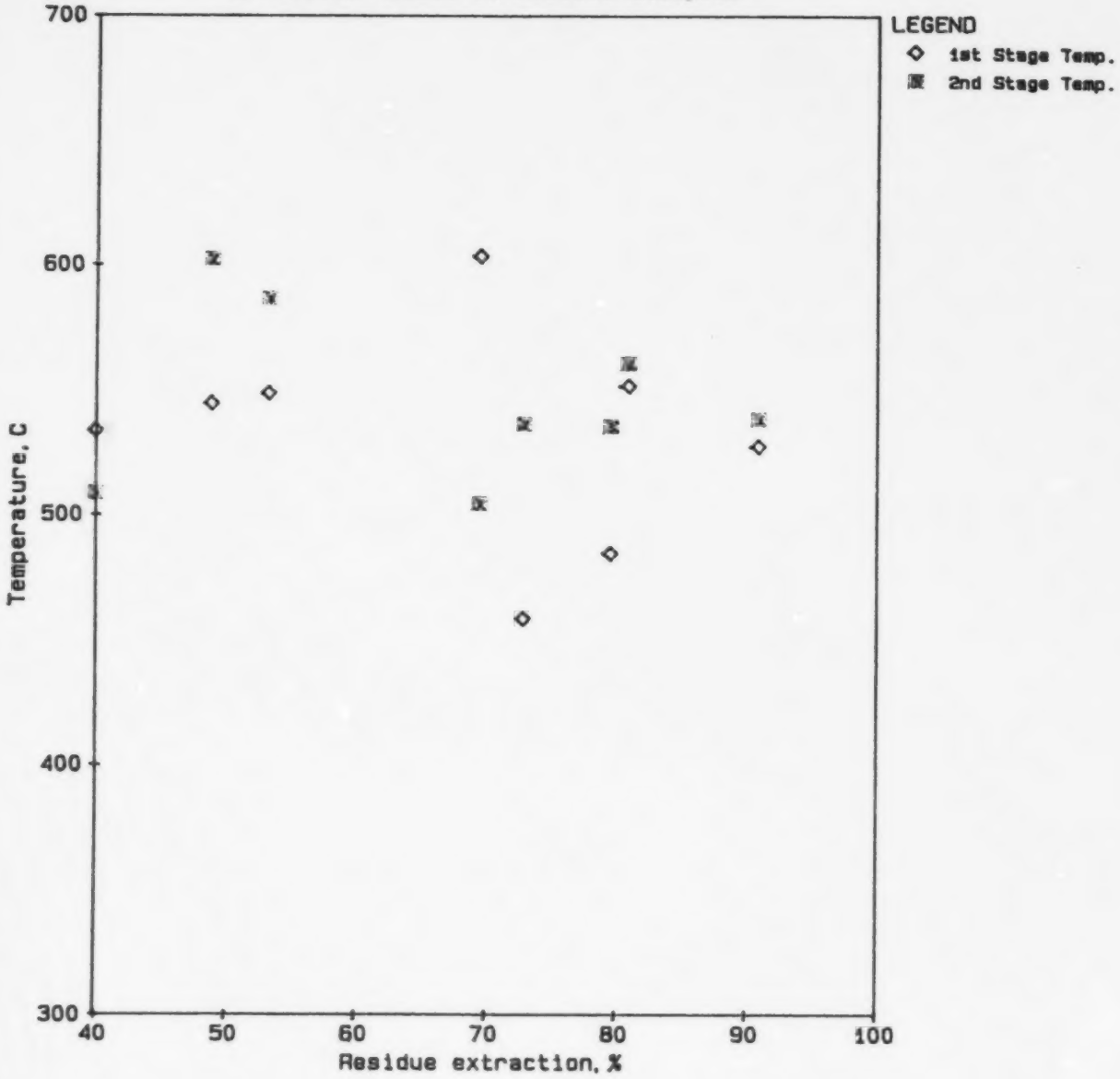


FIGURE 8

1ST STAGE ASSAY

1st stage %As vs CN~ consumption

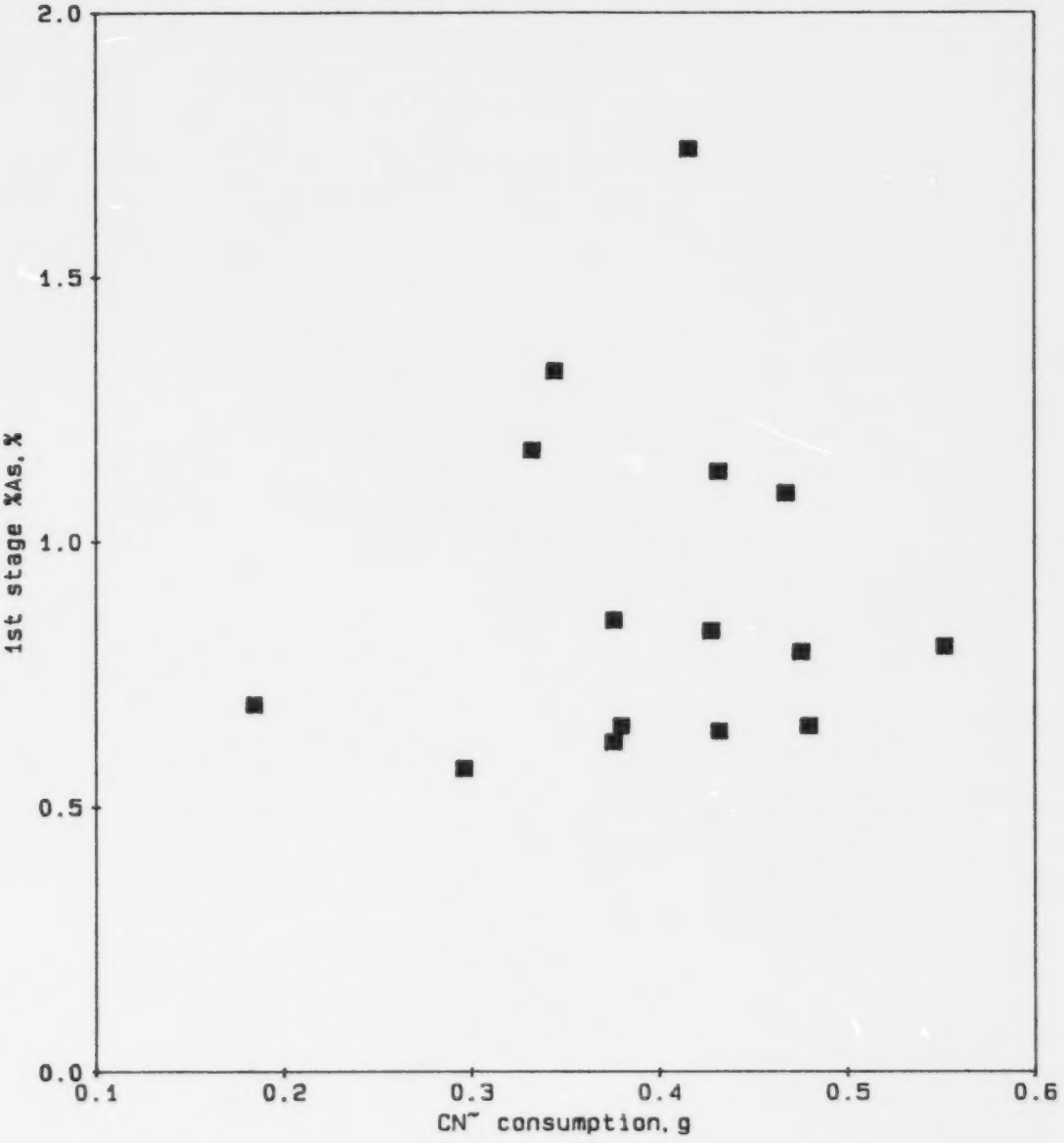


FIGURE 9

1ST STAGE ASSAY

1st stage %S vs CN~ consumption

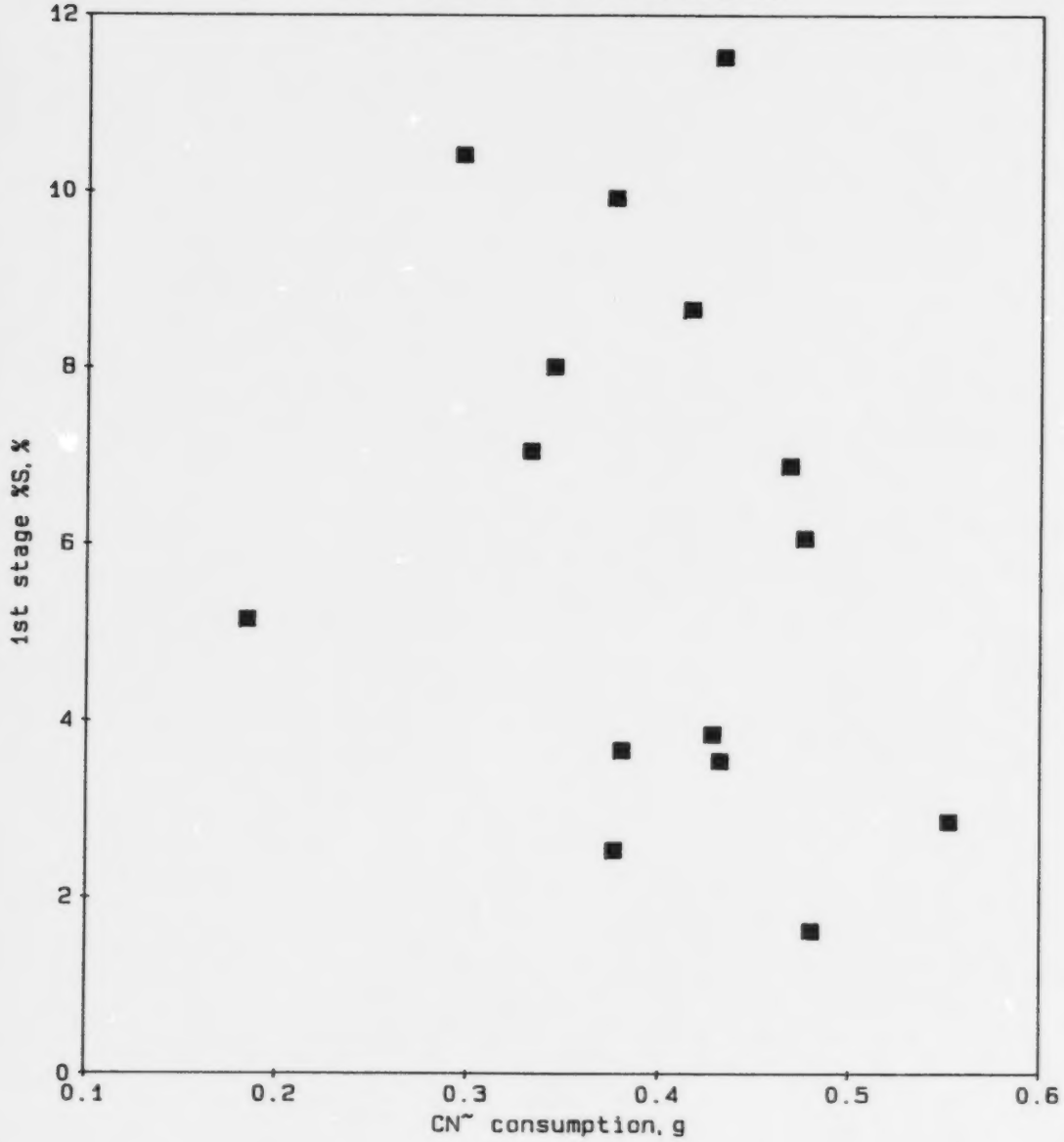
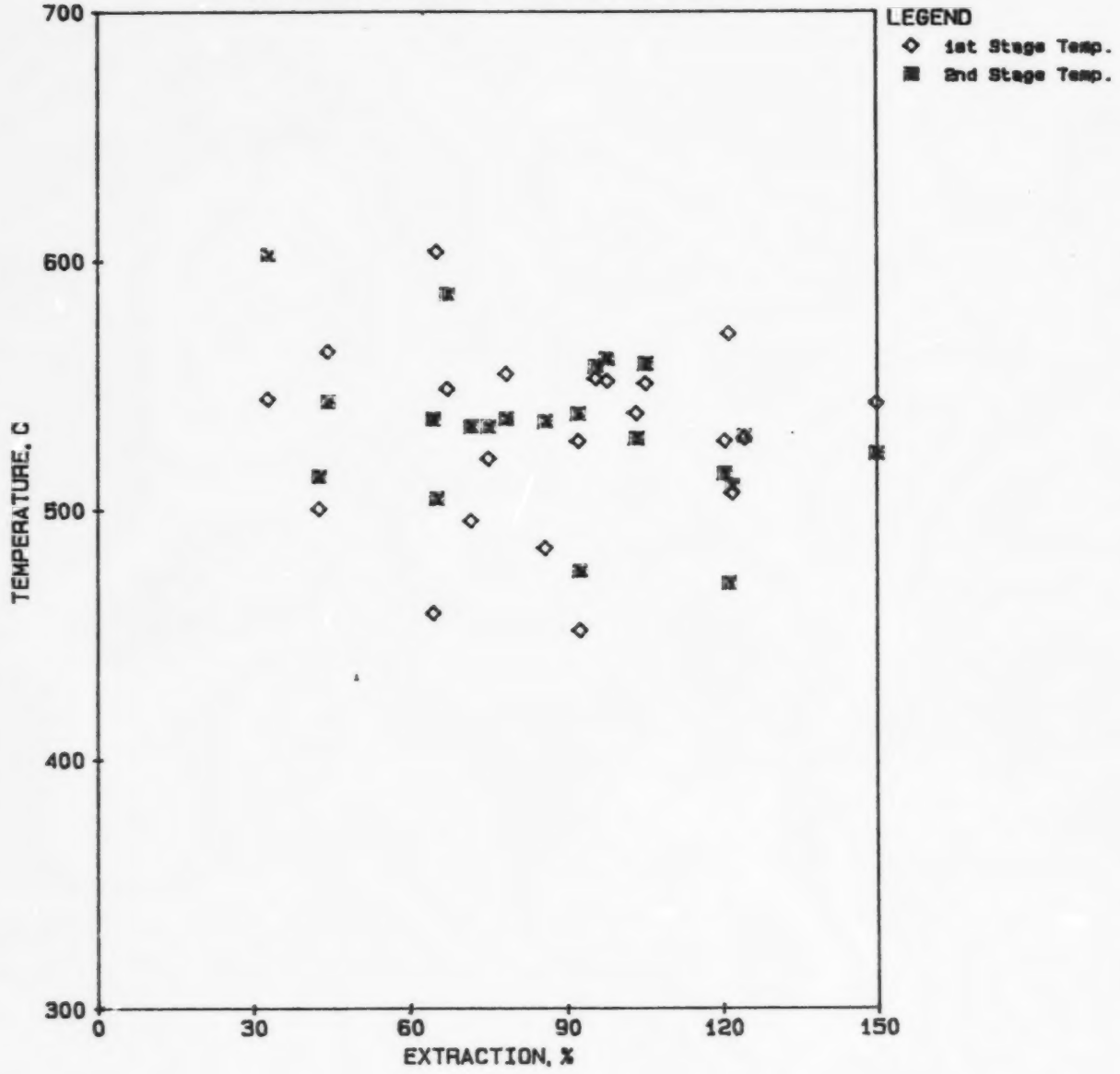


FIGURE 10

TEMPERATURES VS BED OVERFLOW EXTRACTION
EXTRACTION BASED ON SOLUTION EXTRACTION



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